THE

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CONTENTS:

	PAGE
Automatic Block Signalling	781
The Belgian Electric Railway	784
Multiphase Transmission and Distribution of Energy (*illustrated*)	784
Secondary Cells: New Researches	785
An Explanation of the Magnetic Character of Certain Cells ...	785
Three-Phase Alternating Motors	786
Reviews:—	
Modern Views of Electricity.—Electric Ship Lighting ...	786
The Burke Cable Relay and Transmitter	787
Automatic Railway Signalling	787
A New Method of Field Excitation	789
Experiments on Alternate Current Arcs	789
Elmore Companies	790
Legal:—National Telephone Company *v.* Graff-Baker	792
St. Pancras Electric Light Station	794
Notes	796
Contracts Open and Closed	798
Business Notices, &c.	798
City Notes, &c.:—The Fowler-Waring Cables Company ...	800
Yorkshire House-to-House Electricity Company	801
Elmore Foreign and Colonial Copper Depositing Company	801
Elmore Wire Company	802
Elmore Patent Copper Depositing Company	803
The Woodfield Syndicate	803
The Edinburgh Electric Supply Company	804
The Oxford Electric Company...	804
The Crystal Palace District Electric Supply Company ...	804
Traffic Receipts	804
Share List of Electrical Companies	805
Proceedings of Societies:—The Institution of Electrical Engineers (*continued*)	806
New Patents.—Abstracts of Published Specifications	811
Correspondence:—High Pressure Steam Generators	812
Raising Mercury	812

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UNIVERSAL ELECTRICAL DIRECTORY

For 1893

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AUTOMATIC BLOCK SIGNALLING.

IN another column will be found the description of an automatic electrical block signalling system with which we have been favoured by the Automatic Electric Railway Signal Company, Limited.

The description afforded does not go very fully into detail, but so far as we can gather, the principle involves the retention of the signal governing the movement of the trains in the *all clear* position by the action of the current, the absence of which causes the signal to fall by gravity to danger. The principle thus enunciated is a proper one. It is right that any defect, want of power, breakage of wires, or other deficiency or irregularity, should place the signal in the danger position. Treadles, operated by the passing train, are employed for bringing the battery current into play. Taking an intermediate station for the purpose of illustrating the action of the principle involved, the train, on entering the station, passes over one treadle, which places the signal to danger by *breaking* the circuit. It then passes over another, by means of which it *makes* a second circuit. The first named circuit proceeds to the signal-post in advance; the last-named to the signal-post in the rear. In breaking the one circuit it has placed a signal at danger to protect it from following trains. In making the other circuit it has put a current of a momentary character upon the line wire communicating with a relay at the post in the rear, and thereby lowered the signal there to the all-clear position. This is repeated as may be required between post and post, and may be applied to any number of signals.

The system is one, we should say, likely to be very much more appreciated in the States than in England. In detail, it possibly possesses advantages over other like systems; and on paper, and in theory, all such schemes present a most pleasing method of meeting those difficulties which attend the present disjointed working of the block systems generally employed. But we are obliged to admit that, ingenious as these systems are—displaying, as many of them do, a vast amount of thought and application—we see little probability of their employment.

What would be the result to our crowded main lines with such a system in use, were it to become out of order? Stoppage of the entire traffic, or disregard of the block! Such must be the issue; and will anyone, having a knowledge of railway telegraph work, be bold enough to say such an arrangement never will fail?

There are other points in this scheme which do not commend themselves to our consideration, but which we do not think it necessary to enter upon. The inventors may, however, rest assured that British railway companies will never adopt an automatic system which is not under the immediate supervision and entire or joint control of a human agency responsible for its due and efficient action.

Measuring the Calorific Power of Fuel.

UNDER the auspices of the Society for the Encouragement of National Industry in France, Mons. Mahler has recently concluded some researches, the object of which was to obtain accurate values for the combustible power of various kinds of coal. He used for this purpose a modification of the calorimetric shell of Mons. Berthelot. The modifications have the approval of Mons. Berthelot, which is the surest guarantee that they in no way detract from the scientific value of the method, while on the other hand the approval of engineers and *savants* interested in the industrial applications, testifies to the simplicity and manageableness of the apparatus. The shell is made of forged steel and highly polished; it has a capacity of 654 cc., its walls are 8 mm. thick, and it weighs, with its accessories, 4 kilogrammes. It is nickel plated on the outside; within it is coated with thin enamel to preserve it from corrosion or oxidation. The cover is of iron, and carries on its inner surface a ring of lead, which fits into a corresponding circular groove, cut in the rim of the shell. Compressed oxygen can be admitted by a conical stop cock of nickel iron. Through the cover passes a well insulated electrode, prolonged on the inside by a rod of platinum; the cover also carries another similar rod of platinum, to which is attached the plate or capsule upon which the combustible is placed. Attached to the two platinum rods is a small spiral of fine iron wire, and ignition of the combustible is caused by sending an electric current through this at the desired moment. The source of electricity may be either a magneto-electric machine or a battery, which should be capable of giving a current of 2 amperes under a pressure of 10 volts. The method of determination resembles in principle other calorimetric operations, and need not be specially described here. We understand that Mons. Mahler's apparatus is rapidly being introduced into both scientific and industrial laboratories in France. The report of the committee of the Society for the Encouragement of National Industry appointed to consider this instrument, contained the following statement: "In thus placing in the hands of manufacturers a method by which they can themselves ascertain with precision the calorific power of the combustible they use, Mons. Mahler has rendered to national industry a service greater even than could result from the actual determinations which he has made."

The Application of Electricity to Dentistry.

A RECENT paper by Mr. Albert C. Westlake, D.D.S., on the application of electricity in dental practice is in many ways very suggestive, although we cannot help thinking that, if dental surgeons are seriously going to introduce electricity into their professional work, they had better make some attempt to master the elementary principles of electrical science. Possibly Mr. Westlake only regards himself as a student in such matters; at any rate we recognise that they lie without the usual curriculum of a dentist's training, and so we will not criticise the rather crude knowledge which he displays of the agent which he is attempting to impress into the service of dentistry. The root of the matter is reached when Mr. Westlake states that in the application of electricity to dental practice the object aimed at is necessarily localised electrisation. This is accomplished, he says, by so placing the electrodes that the current in passing from one to the other shall chiefly traverse the particular portion of the body of a patient that is affected, so far as the operator can control it. The effect of both the faradic and galvanic currents, however, extends directly, or by reflex action, to parts beyond the circuit. These currents have often been confused in their physical and physiological effects. They are, of course, the same force (why *will* people call electricity "a force?"), only there is a difference in potential and quantity, says Mr. Westlake, and for either to be applied successfully the operator must be competent to diagnose or to decide which to use. Thus, if merely an intermittently contractile, or simulative effect on muscle is desired, the use of rapidly interrupted current at high pressure, such as is obtained from a faradic coil, is indicated; while if a cataphoric effect is desired, a current of volume is necessary. Obviously the operator should have the current under complete control, both as regards pressure and volume. Mr. Westlake assumes that it takes twenty times more pressure to overcome the resistance in the tooth than in the soft tissue. The conductivity is also modified by age, temperament, and the nature of the disease. Hence greater quantity is used in dealing with a patient who is advanced in years than in the case of a young patient; moreover, greater quantity appears to be desirable in operating upon patients possessing a lymphatic or bilious temperament than if the temperament be of the nervous or sanguine type. Mr. Atkinson is convinced that the problem of obtunding sensitive dentine will be solved through the agency of electromedication or cataphoresis. This theory, as applied to other tissue, was promulgated by certain French scientists fully fifteen years ago. His own experiments in this direction are, at present, not very extensive, but the favourable results obtained encourage the hope that after the differential actions of the two currents on bone are thoroughly understood and the decision made as to the proper drugs to be used, the pain that patients experience when a tooth cavity is being prepared will be reduced to a minimum. A few experimental cases are reported by the writer of this paper, from amongst which we select the following:—"If the positive and negative poles are brought into firm contact on the gum at both sides of the root or tooth to be extracted, the ends of these electrodes being of cup or saucer-like form, within which is placed sponge or cotton saturated with a four or six per cent. solution of cocaine, absolute alcohol, or mixed ether and chloroform, and then if the current be gradually turned on to the required strength this preparation is made to permeate the tissue sufficiently to cause local anæsthesia, and the subsequent extraction of the tooth is consequently painless."

The Effect of Additions of non-electrolytes on the conductivity of Solutions.

WE recently called attention to an interesting investigation upon which S. Arrhenius has been engaged, which had for its object the examination of the electrical conductivity of substances in mixed solvents. He found, it may be remembered, that when a portion of the water in the aqueous solution of an electrolyte is replaced by a non-electrolyte, such as alcohol, so that the total volume remains the same, the electrolytic conductivity of the solution diminishes. Fifty-five different electrolytic solutions were investigated with regard to the influence on their conductivity of six non-electrolytes, namely, methyl, ethyl and isopropyl-alcohols, ether, acetone and cane sugar, the strengths of the solutions and the quantities of added electrolyte being varied. Since our notice of this work, which may be found *in extenso* in the *Zeit. Physikalische Chem.*, Vol. ix., pp. 487—511, more work has been done in the same direction by R. J. Holland (*vide Berichte der Deutschen Chemischen Gesellschaft*, xxv., pp. 2,726—2,727). His investigation differs from the researches of Arrhenius in that the non-electrolytes employed (benzene, toluene, xylene, and turpentine oil), were none of them solvents of the salts examined. Purified methyl alcohol, dried by distillation with anhydrous copper sulphate, was the solvent used, solutions of 1/100, 1/1,000, and 1/2,000 normal concentrations being investigated with successive additions of 5, 10, 15, and 20 per cent.

by volume of the non-electrolyte. The following general conclusions were arrived at in respect to lithium, sodium, and potassium nitrate :—1. The reduction of the conductivity by the addition of a non-electrolyte is proportional to the amount of the latter added. 2. The reduction of the conductivity varies according to the nature of the dissolved salt and that of the non-electrolyte. 3. The graphic representations of the molecular conductivities are straight lines.

The deposition of Gas by the Chemical Society: a splendid Testimonial.

OUR learned societies have often been termed the aristocracy of English intellect, and we may further credit them with maintaining that perfectly open mind which is a characteristic of those who have been through a scientific training. This is especially true of the Chemical Society, which, as the late Prof. Hofmann said as long ago as 1863, has ever "loudly claimed the cosmopolitan character of science. The concerted action of this society, whose highest aim is to add contributions to the common treasury of knowledge, is, we think, of greater import than all the resolutions and discussions of any body of men, the individuals composing which are held together by the ties of self-interest. All this, we take it, will be unanimously conceded; and now we pass from our introduction to our illustration, which will be seen to be pregnant with argument in favour of the superiority of electricity over gas as an illuminant. On taking the chair at the first meeting of the Chemical Society, session 1892-1893, Sir Henry Roscoe congratulated the Fellows on the very great improvement effected in the Society's rooms, especially in the theatre, during the recess. The treasurer, Professor Thorpe, agreed with the chairman in thinking that the Fellows present had good cause to congratulate themselves on the changed conditions under which they met. The theatre, or meeting-room, had undergone what was practically complete reconstruction, with the result that better light, better ventilation, and better accommodation had been secured. Moreover, it would be noticed that the electric light had been substituted for gas as an illuminant throughout the building; this, it was hoped, would promote the comfort of Fellows attending the meetings, not only in its effect on the nature of the air within the rooms, on the cleanliness of the apartments, and on the preservation of their decorative character, but also by affording greater facilities for the exhibition of specimens, diagrams, and lantern projections. [The professor incidentally gave a practical illustration of this last advantage later in the evening when, in the course of the discussion on a paper by Mr. S. U. Pickering, entitled "The hydrate theory of solution," he demonstrated certain solution phenomena by throwing an image upon the screen by means of the electric light.] On the motion of the chairman, seconded by the treasurer, it was resolved that the best thanks of the Fellows be tendered to Mr. Martin L. Saunders, by whom the structural alterations had been planned and superintended, and to Prof. Ayrton, to whom the Chemical Society was under a very special obligation for the great amount of time, thought, and energy which he had expended in planning the installation of the electric lighting. Now in order to appreciate the true significance of this deposition of gas in favour of electricity by the Chemical Society, it must be borne in mind that a large percentage of the Fellows are directly interested in gas, and in the bye-products arising from its manufacture. The preparation of this illuminant is essentially a chemical process, and therefore one to be viewed with favour by men possessing a chemical bias. Moreover, is it not a fact that very many of the Fellows derive substantial additions to their incomes through the professional work which they are called upon to perform in connection with the coal-gas industry, *e.g.*, in improving and testing the quality of the light; the utilisation of bye-products, &c. We lay stress upon these facts in order to assign more honour to the Fellows of the Chemical Society in deciding to adopt the electric light in the Society's rooms, and because we think they serve to emphasise the high value of this adoption as an object lesson to the country at large. In our opinion, this action of the Chemical Society is one of the most severe blows which the gas companies have yet sustained, and will be regarded by electrical engineers as a splendid testimonial.

A New Method of Preparing Filaments for Incandescent Lamps.

AN English contemporary contained an article last week on what is stated to be the method of treating filaments employed by the Actien Gesellschaft für Elektrische Glühlampen, the subject matter being taken from a German source. Had the process described been published 10 or 12 years ago, we should not have been so much surprised, but we must confess to being astonished at seeing so remarkable a jumble in print after so many years of experience in lamp manufacture. We do not, we may add, believe for a moment that the celebrated Austrian factory really make use of such processes. Here is an extract from the article giving the procedure followed :—"The wooden, silk, or cotton thread is steeped in a solution of water-glass, 25 to 30 per cent.; senegal gum, 10 to 15 per cent.; caustic soda, 12 to 13 per cent. It is then rolled, being bent into the form of an angle iron, this form having the advantage of possessing many edges, which, says the *Zeitschrift*, are known to be more luminous than surfaces. The filament is then carbonised in the usual manner, and replaced in the paraffin bath, the paraffin solidifying round it; the necessary arrangements for measuring their resistance are made; the current is passed and particles of carbon are deposited on the silicate sheath. When the filament attains the proper resistance the current is cut off, the bath of paraffin is melted, and the filament removed; the particles of paraffin are cleared off by alcohol, and the filament is then ready to be fixed in the lamp." In another part of the article we are informed that "the mineral gum melts during the carbonisation (baking) to form a non-conducting sheath of silicate which serves not only to protect the filament from burning during the process and from air, but also gives it a smooth surface . . . ." If the baking is performed in the *usual* manner, as above stated, viz., by packing the blocks supporting the filament material in powdered plumbago, it is difficult to see how it happens that the plumbago does not adhere to the fused silicious surface and thus seriously impair its beauty; or even if the plumbago be omitted and the operation conducted in a gas to see how the filaments are stripped off the blocks. We are also given to understand that in the usual manner of "carbonising" (flashing) filaments in a "liquid or gas, the currents set up by the heating hinder the process, owing to the contained oxygen acting on the depositing carbon and spoiling its quality." The general public may not, perhaps, be aware what sheer nonsense this is, but many a lamp manufacturer knows that with certain hydro-carbons and under certain conditions the presence of a small proportion of air has a highly beneficial influence. Several other absurdities and errors might be enumerated, *e.g.*, the fact of an excessive development of blue halo and "arcing" in the lamps in cases where the filaments have previously come in contact with salts of sodium; the electrolytic action that must go on with a filament impregnated with a highly alkaline silicate when under the influence of the current, &c., but enough to this end has already been said.

THE BELGIAN ELECTRIC RAILWAY.

INTERVIEW WITH M. P. VANDENKERCHOVE.

[FROM OUR OWN CORRESPONDENT.]

THE promoter of the electric railway from Brussels to Antwerp, M. Prosper Vandenkerchove, being at present in Brussels, we have caused him to be interviewed, to learn the present state of the question.

According to his declaration, "the application for a concession for the electric railway from Brussels to Antwerp was deposited on November 2nd. Two proposals have been submitted to the State. According to the former, the State executes the direct duplication of the present line, which has become indispensable. Upon this line we engage, at our own risk, to convey in electric carriages all the direct passenger traffic between Antwerp and Brussels. We shall account to the State for the suppression of its present profit on the service in question."

"If electric traction presents difficulties, it will always be possible to work with steam. Thus there will be no loss. But the applicants are assured of the contrary."

"If the State finds the business good, it can resume it at pleasure. If not, it leaves us the electric working, the returns of which it will draw. Hence there is no risk to the State, and no concession in the ordinary sense of the word."

"The second proposal made to the Government is, that we carry out at our own expense the direct line, the working of which, by steam, would at once improve the present position. The State engages merely after the lapse of a certain number of years, to be fixed according to the interests of the State, *e.g.*, by annuities. The result is clear: by our intervention the State, without any sudden expenditure, becomes at once the proprietor of a line, which it soon cannot dispense with. Further, we undertake to establish electric traction always on the same footing."

"Hence there is no possible risk to the State, no shadow of the concession of a railway, and no difficulties for the budget."

"As regards the execution of the project, I wish to put the State in a position to endow the country with a great undertaking. There is no opening here for venal pre-occupations, financial combinations on a large or small scale, neither concession nor monopoly. Some months ago I commenced negotiations with the Government, and the favour with which the Ministry have received the first exposition of my ideas, showed me at once that they understood the utility to the country of the creation of an electric line from Brussels to Antwerp. This sentiment was just and well founded. Of this I need no other proof than the noise which is daily made concerning this idea of electric traction."

"Since then the Congress at St. Petersburg has thrown the mantle of its authority over my hope of establishing electric traction in the future."

"The trials which the State proposes to make some day or other in a totally different direction by means of accumulators shows its tendencies to follow the general current."

"As to the possibility of executing my project from Antwerp to Brussels, I do not hesitate to declare that I have entire confidence in the success of the enterprise. It has two parts, the track and the material. The tracings and the sections, as well as the constructions which form the line, have formed the subject of a special study on the part of competent functionaries. As for the materials, which must be the task of specialists in the arts of the engineer and the electrician, we must necessarily have recourse for their construction to private industry, reserving for national industry all that it can produce."

"The confidence of the electricians of the entire world in the success of the project is so great, and is founded on so many actual facts that I have received from the most important firms proposals to supply the plant."

"In my opinion, there is in the execution of this new project nothing which is of an experimental provisional character."

"It may be said that the line is the first of its kind. I reply it will be the first electric line between two cities like Brussels and Antwerp, because in no part of the world are there two cities having such constant intercourse and separated from each other by so short a distance. Why should Belgium wait, considering that 6,000 kilometres of electric railways intersect America. We are ready to make a considerable effort, and we demand no sacrifice from the Government."

"The duration of the execution of the work depends on the Government, which is in every respect master of the situation."

MULTIPHASE TRANSMISSION AND DISTRIBUTION OF ENERGY.

BY A. RECKENZAUN.

IN the issue of the ELECTRICAL REVIEW for April 29th, I described with the aid of drawings the Lauffen-Heilbronn drehstrom installation. Through the courtesy of Mr. Oscar von Miller I am now in a position to bring a few additional details which may be of interest to those of your readers who have followed up this subject. The construction of this unique plant was commenced on September 15th, 1891, and current was furnished to consumers at Heilbronn on January 10th of the present year; consequently, the machinery has now been in continuous operation for nearly twelve months.

Although the ultimate capacity of the hydraulic power station at Lauffen is calculated for 18,000 "wired" 16-C.P. incandescent lamps or their equivalent in energy for arc lamps and motors, there were in November, 1892, only 1,700 glow lamps of 16-C.P., 20 arc lamps, and 11 multiphase motors of the aggregate of 32 H.P. in actual use. The demand, however, is said to be rapidly increasing, and the second set of turbine and generator will soon find useful work. The contractors are the Portland Cement Works, of Lauffen, and they have bound themselves to supply the consumers with lamps taking not more than 3·3 watts per candle-power, and with a durability of at least 800 hours. Furthermore, they guarantee that the electric motors shall not consume more than 900 watts per actual horse-power. The price charged for energy is 7·5 pfennige for 100 watt hours, which is equivalent to about 9d. per English Board of Trade unit; a high price considering the cheap method of obtaining power; this is for illuminating purposes. Current for electric motors and for heating and electro-chemical uses is charged at the rate of only 3 pfennige per 100 watt hours, with discounts of 7½, 15, and 20 per cent. if the number of working hours are 1,250, 1,500, and 2,000 or more, respectively, per annum. The capital expenditure up to date has been £13,000, and this includes the power station, wires, and poles carrying the 5,000-volt current, a distance of 10 kilometres, main and sub-transformer stations, and about 8 kilometres of underground concentric cables in the streets of Heilbronn. As already mentioned in my former communication on this subject, the E.M.F. of the generator is 50 volts, which is transformed up to 5,000 volts, carried through three bare copper overhead wires, each 6 millimetres in diameter, to the outskirts of Heilbronn, where it is transformed down to 1,500 volts, and distributed underground in concentric cables to about 25 small transformers which convert the current into 100 volts for use in the houses. Fig. 1 shows a section of the treble concentric cable, and fig. 2 the section of a junction box.

The various losses in the transmission and distribution leads have been calculated as follows: in the long distance transmission, high tension wires, 10 per cent.; concentric distributing mains, about 2 per cent.; and in the secondary net work, 1½ per cent. During the hours of least load at Heilbronn, the turbine and dynamo at Lauffen are loaded to nearly their full capacity, and the surplus electric energy is utilised for heating and drying of clay at the cement works, which formerly demanded the consumption of many tons of coals per annum. This constant loading of the generators also insures better regulation, for, during the hours of small loads, when motors are suddenly thrown on and off the regulation of the turbine speed becomes difficult and troublesome. The application of multiphase motors has fully justified all expectations, and they give general satisfaction. These machines have neither commutators nor contact rings, they

are, therefore, not subject to any appreciable wear and tear. The only moving part is the rotating iron cylinder, which is set in motion by the simple turn of a switch. A motor of 8 H.P. capacity occupies only one square metre of floor space; its lubricating arrangements are such that no attention whatever need be paid to the machine for 8 and even 14 days at a time. This is an advantage which can be fully appreciated by those who have to set up machinery in places difficult of

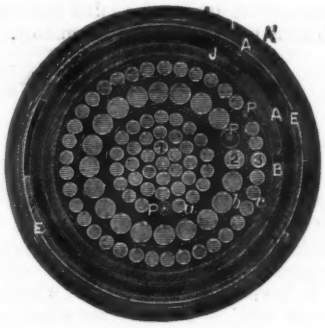


FIG. 1.

FIG. 2.

access; and as to the absence of commutators and brushes, such machinery lends itself admirably for fiery mines without any of the precautions necessary in all other electric motors. In order to prevent flicker in the electric light at the moment of starting the larger types of motors running on the same circuit, there are liquid resistances provided which are so arranged that the full current required by the motor cannot be obtained in less than 15 to 20 seconds, thus ensuring a gradual start. A report from the Portland Cement Works states that the installation has worked without a hitch, and the details of construction and general safety leave nothing to be desired.

SECONDARY CELLS: NEW RESEARCHES.

A NEW contribution to the theory of secondary batteries has recently been made by F. Streintz, to whose researches in this direction we have frequently referred. He has now demonstrated the presence of hydrated peroxide of lead as a secondary product on the plates of these elements by means of a series of measurements referring to the electromotive force.

Streintz expressed the opinion that the formation of hydrated peroxide of lead is accompanied by a diminution of the electromotive force of the secondary cell on charging, whilst when this substance is transformed into something else ("destroyed" he rather loosely terms it), there is a corresponding increase in the electromotive force when the cell is discharged.

The significance of the degree of concentration of the acid on the electromotive force has been more than suspected by several workers, consequently Strientz conducted some experiments with a view to determining the dependence of the E.M.F. on the condition of the acid in the cells. He finds, on considering the data obtained from this part of the investigation, that, if the electromotive force is expressed in volts, and the concentration of the acid in grammes of $H_2 S O_4$ per litre of cell acid, the following relation holds good for ordinary temperatures:

$$E_z = 1{\cdot}850 + 0{\cdot}000572,$$

when E is the E.M.F. in volts, and z the strength of the acid. When, however, the specific gravity of the solution is taken into account, the relation is expressed by the following formula:—

$$E_s = 1{\cdot}850 + 0{\cdot}917\ (s - s_0),$$

where E is the E.M.F. in volts, s the specific gravity of the acid solution, and s_0 that of the water at the temperature at which the experiment is made.

In all the experiments Streintz observed that the temperature coefficient of the electromotive force was positive.

The measurements were made at every fifth degree, and extended over a range of 60°, namely, from 10° to 70° Centigrade.

The following are the coefficients of temperature for various values of the electromotive force:—

E	$\frac{d\,E}{d\,T}\,10^6$
1·9223	140
1·9828	228
2·0031	335
2·0084	285
2·0105	255
2·0779	130
2·2070	73

The above statements represent the pith of Streintz's investigation. Some of our readers, however, who may be specially interested in the theory of secondary cells, will like to consult the original paper, this may be found in full detail in the *Ann. Phys. Chem.*, Series 2, Vol. xlvi., pp. 449—463.

AN EXPLANATION OF THE MAGNETIC CHARACTER OF CERTAIN OXIDES.

IN the manufacture of nickel the metal is sometimes granulated by pouring it, when molten, into water. This operation usually proceeds quietly and without interruption; but occasionally sharp explosions take place as the metal touches the surface of the water. Investigation into the conditions of these explosions have shown that the phenomenon is always accompanied by a more or less oxidised state of the molten metal; that is to say, the nickel ore has not been completely reduced to metal in the operations preceding that of granulation.

It is also noticed that when no explosions occur, and when the molten metal sinks quietly to the bottom of the granulating vessel, bubbles of gas rise to the surface of the water and burn there with a blue flame.

Inasmuch, then, as the fully-reduced metal appears to decompose water like an electric current does, and as the partially reduced metal causes an explosion when coming into contact with water, it would seem that, in the latter case, the presumably homogeneous mass of molten metal consists partly of molecules of free nickel which liberate hydrogen from water, and partly of molecules of nickel oxide which supply oxygen and at once combine explosively with the hydrogen.

This explanation, namely, that an oxide of nickel probably exists in which the mass is partly metallic and partly oxidised, suggests an analogous explanation of an analogous phenomenon, that is, the magnetic character of certain oxides.

Hitherto, authorities like Mendeléef, Drechsel, &c., have considered that magnetic oxide of iron, $Fe_3 O_4$, is composed of ferrous and ferric oxides, and have "rung the changes" on the valancy of iron, in order to help out their explanations; but none of the views which have been expressed, throw any light upon the most remarkable property of $Fe_3 O_4$, namely, its magnetic character, that is to say, they show no reason why it should be much more magnetic than its fellow oxides, and especially the protoxide, which contains a larger proportion of iron.

Mr. Stephen H. Emmens, of the Emmens Metal Company at Youngwood, Westmoreland County, Pa., U.S.A., has recently discussed the various ways in which the constitution of magnetic oxide of iron may be considered. Arguing from isomorphism and the phenomena of solution, he concludes that there is no good reason for regarding magnetic oxide of iron as $Fe_2 O_4 = Fe O, Fe_2 O_3$—the common view.

He then adduces various arguments against this view; these are derived from:—

1. The saturated character of $Fe_2 O_3$, which prevents it from becoming linked with Fe O.

2. The unstable nature of Fe O, which should result in the further oxidation of $Fe_2 O_3$, a result which does not occur, because we know that magnetic oxide of iron is often used now as a durable coating for the purpose of preventing iron from rusting.

3. The conflicting statements of Becquerel, Mendeléef, Plucker, Sidot Frewsel, and Malaguti, regarding the magnetic character of the various oxides of iron.

4. The fact that whilst the hydrates of Fe O and $Fe_2 O_3$ are not magnetic, the hydrate of $Fe_3 O_4$ is attractable by the magnet.

5. Lefort's chemical experiments (*vide Comptes Rendus*, lxix., p. 179).

6. The theories of Moissan and Berthelot regarding the specific gravities of the oxides of iron.

From these and other arguments deduced from the valency of iron, and taken together with the phenomena observed during the granulation of nickel, Mr. Emmens concludes that in the magnetic oxides some part of the metal must exist uncombined with oxygen, though intimately mixed with the metallic oxide, and hence the oxide appears as though it were itself magnetic.

THREE-PHASE ALTERNATING MOTORS.

By RANKIN KENNEDY.

MR. EMIL KOBBEN, of the Oerlikon Works, has answered my question as to whether this class of motor was any "good anyhow," by giving us a table of actual tests made under his own supervision; but at the time when I put the question we had no tables of actual tests made with three-phase motors.

This is the table given; it shows remarkably good results for alternating current motors, and to some extent disposes of the objections raised against them in relation to their large exciting currents and small starting torque. But, however good this class of motor may be for transmitting power to a distance electrically, yet it is not much good commercially, at any rate not in this country. In the first place, to get over the difficulty of the large exciting currents very low frequency is necessary—much lower than we are inclined to use for any other purpose than transmission of power. In the next place all our alternating current supplies are simple, so that three-phase motors cannot be used on them at all; and in the next place, although three-phase motors work all right on a purely motor system, yet, if motors and lamps are simultaneously worked on a three-phase system, troubles immediately arise due to the impossibility of keeping the lamp load equal. I am aware that incandescent lamps with three legged filaments and three terminals can be used, thus equalising the lamp load, but such a lamp can be used in a complete three-phase system. Arc lamps have not been workable on this system; they also would require three carbons all feeding towards a common centre.

Altogether there is certainly some work before those electricians who have undertaken the commercial introduction of three-phase motors for any other purpose than the transmission of power over long distances. In this country the simple synchronous reversed alternator motor finds most favour, although it does not meet the requirements for the supply of small domestic motors. Even in America, where multiphase motors first appeared, we find the most important motor work is done by synchronous alternators.

TESTS OF TRIPLE-CURRENT MOTORS.—TABLE GIVING RESULTS OF TESTS OF SIX SIZES OF STANDARD OERLIKON TRIPLE-CURRENT MOTORS.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Nominal size of motor.	Frequency.	Revolutions per minute running free.	Revolutions per minute under full load.	Maximum starting torque in pound-feet.	Full load torque.	E.M.F. between terminals and the neutral lead.	Current in each branch at no load.	Current in each branch running at load of column 12.	Power taken at no load.	Power taken at load in column 12.	Output delivered at pulley during duration test of four hours.	Output delivered at pulley during duration test of four hours.	Commercial efficiency at load of column 12.	Total Weight of Motor.
Horse-power.	Periods per sec.	—	—	Lb.-ft.	Lb.-ft.	Volts.	Amperes.	Amperes.	Watts.	Watts.	Horse-power.	Watts.	Per-centage.	Lbs.
¼	50	1,450	1,320	2·25	·91	60·5	1·3	2·5	105	325	0·23	170	52	93
½	50	1,450	1,335	2·85	1·82	60	4	8	—	670	0·49	368	55	176
1½	50	1,450	1,350	7·1	5·5	57	7	13·8	346	1,900	1·5	1,104	60	220
3	50	1,475	1,380	11·6	10·7	63	7·5	18	404	2,940	3	2,208	75	330
6	50	975	930	70	32·4	61	20	59	—	6,620	7·1	5,300	80	610
9	50	970	900	82	49·	67	25	86	—	10,400	11·5	8,600	83	930

REVIEWS.

Modern Views of Electricity. By OLIVER J. LODGE. Second edition. London: Macmillan & Co.

In this edition, besides several corrections and emendations, a new chapter on "Recent Progress," revised by Prof. Fitzgerald, has been added. Mr. A. P. Chattock has also written five new sections; the latter relate to conduction through gas, the writer supporting the molecular chain view of the nature of gas discharge, as it alone is capable of giving a simple and connected explanation of many of the most striking features of this form of discharge. It is pointed out, however, that the chain theory is not of itself sufficient to account for the very marked differences between the passage of positive and negative electricity from an electrode, and up to the present no explanation of more than a tentative character has been put forward. The writer considers it as not unlikely that the cause of dissymmetry between positive and negative discharge is electrolytic in character. Chemical changes on the vapours of electrolytes when subjected to sufficiently strong electrostatic stress, also pointing in the same direction.

The chapter on "Recent Progress" deals chiefly with the experiments of Hertz. In conclusion, the author says:—

"Progress towards the direct manufacture of light is apparently going on in two different directions. One is by the attempt to construct mechanism or discover principles able to cause and maintain electric oscillations of the desired frequency; the other is to depend on the properties of certain molecules disturbed and thrown into vibrations by comparatively slow electric oscillations, and being thus caused to phosphoresce." What the eventual results of the researches in these directions may be it is difficult to forecast, but they seem likely to be (as has been stated) of vast importance.

Electric Ship Lighting. By J. W. URQUHART. London: Crosby Lockwood & Son, 7, Stationers' Hall Court, Ludgate Hill.

This work contains practical details of the installation and running of electrical plant aboard ship; and while a considerable proportion of the whole is alloted to the treatment of such subjects as the use of electricity in ships of

war and its application to navigating purposes in the mercantile marine, the greater portion is devoted to the electric lighting of steamers. Chapters I. to IV. deal with the prearrangements for electric lighting necessary on the part of the ship-builder, and the class of plant generally used for sea-going purposes. Chapter V. is devoted to the handling of search and signal lights for men-of-war, and lamps for cargo purposes. Chapter VI. contains details, on a practical basis, of the fitting of ships with the distributing system; whilst chapters VII., VIII., and IX. are devoted to testing, overhauling and accessories generally, the methods used at the present time being strictly adhered to.

In the introductory chapter the author takes the hydraulic analogy to explain the general phenomena or laws of the electric current. There is but little unnecessary detail in explaining principles, and the writer wisely does not pad his book with a lot of matter which has no direct bearing on the subject. A large number of pages of the work necessarily possess but little which is not common to books dealing with the general subject of electric lighting. When we come to essential details we have full descriptions of the same kinds of switchboards, lamps, plans of lighting arrangements, &c., which are peculiar to ship lighting. Full details are given, as an example, of the electric lighting arrangements of the *Majestic*, and plans show the general arrangement of circuits. As regards the insulation of a ship installation, the rule given is to "divide 10,000,000 by the number of lights; the result should be the minimum insulation resistance."

Taking the book altogether, there is much to commend in it and little to criticise. It is distinctly a book which of its kind stands almost alone, and for which there should be a demand.

THE BURKE CABLE RELAY AND TRANSMITTER.

THE American *Electrical Engineer*, for this month, publishes a description of a new cable relay and transmitter, the invention of Mr. Charles G. Burke, which claims to have entirely overcome some of the most serious obstacles to submarine telegraphy.

In principle, the relay may be understood by supposing two siphon recorders placed with their coils facing one another at a few inches apart; the two top corners of one coil being connected, respectively, to the two top corners of the opposite coil by silk threads, which thus gear the two instruments together. The coils are connected in series in such a way as to help each other in producing any given direction of motion. A light aluminium bar joins the middle points of the two silk threads. This bar is deflected in a horizontal plane to right or left with every motion of the coils. Fixed to the cross bar is a vertical spindle which receives a corresponding rotation about its axis as the bar is deflected. The contact for the *local* circuit is made by means of a cross-arm carried by the spindle. This contact arm is free to revolve on its supporting spindle by its adaptation to a fine screw cut on the spindle; a rubbing contact ensues from this motion, which, it is claimed, tends to prevent "stixion" at the local contact point, against which the contact arm rubs.

Each of the coils of this relay is compounded of two ordinary coils set at right angles to one another, thus forming a quadruple system of siphon recorder coils. In place of the vertical permanent magnets of the ordinary siphon recorder, Mr. Burke uses, to each compounded coil, two horse-shoe magnets with their like poles presented to each other, each compounded coil thus moves in a four-pole field. The coils are free to move in either direction, and to the extreme limit to which a given direction of current can turn them.

For the better adaptation of the dot-and-dash system to cable working, and for the prevention of the difficulties which grow out of undue prolongations of battery contact in long cables, Mr. Burke has, in addition, devised a transmitter which comes between the operator's key and the cable and regulates the duration of the battery-contact with the line. By using this transmitter, the static charge of the cable is claimed to be made an auxiliary, instead of an obstruction, to Morse cable work. It converts the signals, whether dots or dashes, into momentary signal-charges, the cable being insulated after each momentary charge; the length of time that the cable is allowed to be so insulated at the sending end, after the charge, determines, at the distant station, whether a dot or dash was sent to line. The mechanism is also arranged to send a "rubbing-out" charge to cable, as the operator's key is let up; and, after each completed signal, the line is automatically put to earth.

In this method of transmission, the middle point of the sending battery is connected to earth; the contacts to line are made by means of metallic brushes, one from each end of the divided battery, which rub, alternately, against a contact wheel, to which the cable is connected. This contact wheel is practically an endless W, the brushes being placed one at the top, and the other at the bottom edge of the wheel, a V and a half apart. The brushes are so spaced, with regard to the wheel, that when one is in contact, the other is insulated. It is evident that, with such an arrangement, the line is charged either with zinc or copper current, or insulated, successively, as the wheel is turned through a complete W. The closing of the operator's key completes a local circuit which releases a detent, and thus allows the contact-wheel, which is geared to an electromotor, to move through the space of one V; this brings a brush into momentary contact with it. The line, immediately afterwards, is insulated from both battery and earth, and so remains, until the operator raises his key, whereby the wheel advances another step, and a reverse current is momentarily sent to "curb" the last. An additional lever puts the line to earth whenever the contact-wheel reaches its normal position of rest, which is at the end of every completed signal.

It will be noted that the duration of the line contacts is not dependent upon the time the operator holds his key closed, and that he simply regulates the time when a "marking" current shall be followed by a "clearing" current. In the interval between these currents, the static condition of the cable is analogous to an actual battery charge, in so far as its effect upon the receiving instrument is concerned, provided that the receiving instrument is sufficiently susceptible, and it is by means of this static condition that dashes are produced through this transmitter.

If we are to judge of the efficiency of Mr. Burke's arrangements by results, *i.e.*, the *fac simile* reproduction of the record made with the relay over the Direct States Cable between Ballinskelligs, Ireland, and Halifax, Nova Scotia, a cable length of 2,640 knots, we are bound to confess disappointment. Upon no code with which we are familiar can anything intelligible be understood of the mystic succession of dots and dashes there engraved. It is probable, however, that Mr. Burke will be able greatly to improve these signals; the ingenuity displayed in the design of this beautiful mechanism will certainly find a way to perfect it. From the appearance of the *fac simile* signals, we should be inclined to predict that the direction where improvement is needed is with the contact-points and surfaces of the local circuit. It is also probable that Mr. Burke will find himself reverting to the ordinary cable signals instead of the dot-and-dash system. He tells us nothing about his speed of working—this is an important factor in cable transmission.

AUTOMATIC RAILWAY SIGNALLING.

THE following particulars of a method of automatic signalling have been forwarded to us by the Automatic Electric Railway Signal Company, Limited, of Liverpool. The principal points claimed for this system are as follows, viz:—

1. The action is entirely automatic.

2. Great simplicity in construction and detail, there being an entire absence of complicated mechanism, clockwork, &c.

3. A train may leave a section and set the signal at "clear." Should it, however, from any cause again back on to such section, the signal will again be set at "danger."

4. Any breakage of line wires, accidents to batteries or instruments, sets the signals at "danger."

5. Trains *only* operate the signals, the passing of platelayers' trolleys, &c., having no effect on them.

6. All working parts are carefully protected, so that they cannot be tampered with.

7. Low first cost, maintenance also low, and a saving in wages consequent upon a considerably reduced staff.

8. Single lines may without difficulty be blocked in both directions.

9. Sidings cannot be opened until the main line signals are at "danger," and *vice versâ*.

The system has been applied on a line in the Isle of Wight.

The following description read in connection with the drawings attached will make the action clear. The drawings are diagrammatic. Fig. 1 represents one of a double line of rails, with three block stations, which may be at distances apart as arranged. The arrow represents a train moving in the direction indicated. It has passed signals Nos. 1 and 2, both of which it has placed at "danger." (These two being at the commencement of the line, do not require any second treadle, there being no signal in advance of them.) On the arrival of the train at No. 3, it depresses treadle C connected with the contact *breaker*, A, the upper part of which is insulated, thus breaking the electric circuit, and in consequence

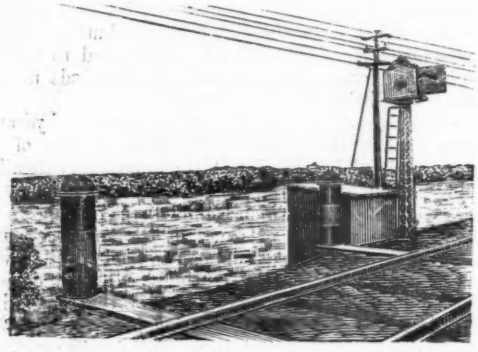


FIG. 3.

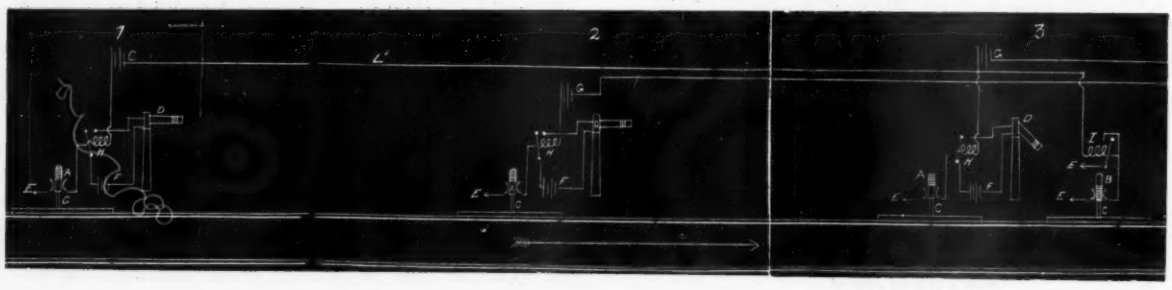


FIG. 1.

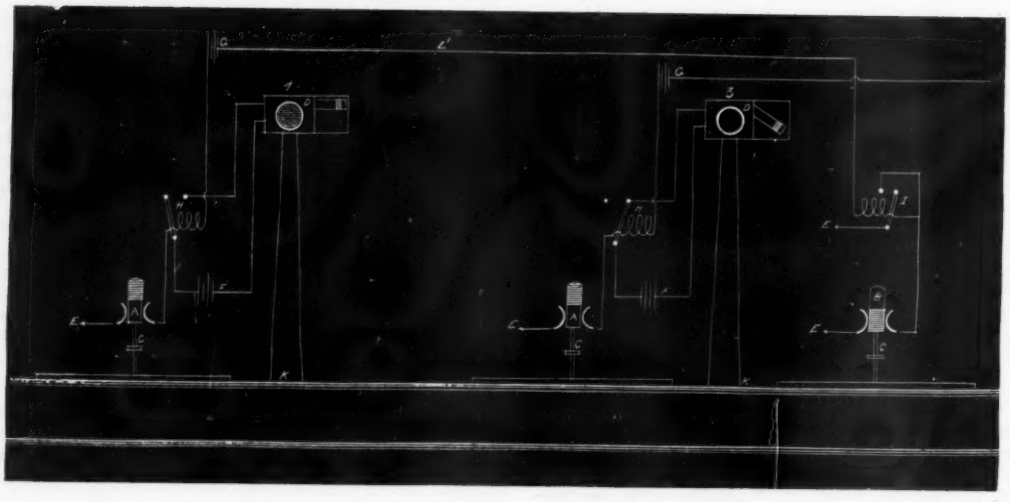


FIG. 2.

releasing the tongue of the relays, H and I, one of which controls the local circuit and allows the signal arm and spectacle to fall by gravity to "danger." Immediately after this the train depresses treadle C, connected with the contact *maker*, B, thus *completing* the electrical circuit through the upper part of B, which is of brass; the relay, I; the line wire battery, G; relay, H; to earth, E.

This causes the armature of the local relay to be attracted, and thus places signal No. 1 at "clear." As the contact made by B is only momentary, the relay, I, is so arranged as to cut out B when the circuit is completed, and introduce a fresh earth, E. The mechanism for actually moving the semaphore and spectacle is contained in D on fig. 2.

Fig. 2 is an enlarged diagram of the electrical connections of signals 1 and 3, which work in conjunction, but it will be easily understood that, if necessary, the signals No. 4 might in the same manner be connected with No. 1, if it was considered necessary to have more than two sections blocked against the passage of trains. The battery power required is very small, and it will be clearly seen that any failure in its action, or the breakage of the line wire, will at once allow the force of gravity to act and bring the signals to "danger."

Fig. 3 is taken from a photograph of the signals actually erected.

It is further mentioned that provision is also made for foggy weather, whereby a loud bell is, by means of a switch, brought into circuit, and rings loudly so long as the signal is at "clear."

Test of the Siam Electric Light Company's Plant.—In accordance with the award of arbitrators, issued in May last, a fortnight's experimental trial has been made of the machinery of the Siam Electric Light Company. The test has turned out satisfactory. By the terms of the arbitrator's award the Siam Company have to pay the Brush Company £9,219 as the balance of the total amount due, and also bear the expense of the trial. In addition to this the Brush Company's agent claims 10 per cent. on the £9,219 from the date on which it became due.

A NEW METHOD OF FIELD EXCITATION.

UNDER the above title, an article appeared in the *Electrical Engineer*, of New York, for December 7th. The writer, Mr. H. L. Tyler, claims to have invented a dynamo which overcomes many of the practical difficulties met in the modern types of machines.

He remarks that, "although the dynamo of to-day is a grand achievement, it possesses numerous disadvantages, and, in attempting to obviate these, the unipolar type of machine invariably suggests itself as the ideal, because it generates a continuous current and needs no commutator to enable it to excite its own magnets." He admits, however, that the results of years of experience have given rise to the general conclusion that "it is impracticable to construct a satisfactory self-exciting dynamo of unipolar design."

We are in accord with Mr. Tyler that a machine without commutator and brushes would be, mechanically, a decided improvement on existing types, but we think that the method proposed by him is not likely to meet with favour. In the first place, although he uses no commutator, in the true sense of the word, yet his design involves two collectors of four segments each, which, though called by him current changers, are just as objectionable, from the engineering point of view, as the brushes and collectors of ordinary machines. In fact, there appear to be no simplification, and, judging from the illustrations, the connections between the armature and field windings (perhaps the most delicate parts of the modern dynamo) are increased in number, while the attendant risks are, of course, multiplied.

The novelty of Mr. Tyler's design lies in the method of exciting the field magnets. His sketches show a stationary armature of the Gramme type, with a revolving field of four salient poles, which are excited successively in pairs. The polarity of the iron is constant in direction, and the armature current is induced by the rotation of the magnetic field. The armature coils are thus traversed by alternating currents, which are not commutated, but fed directly to the field coils through the "pole changers." This method does not appear to be very practicable, or to possess any real advantage over the ordinary method; but Mr. Tyler says "he has repeatedly tested it, with gratifying results, and that there is no sparking even with the dynamo on short circuit."

This is somewhat difficult to understand, and we require some further proofs of its applicability to practice.

EXPERIMENTS ON ALTERNATE CURRENT ARCS.

BY E. WILSON.

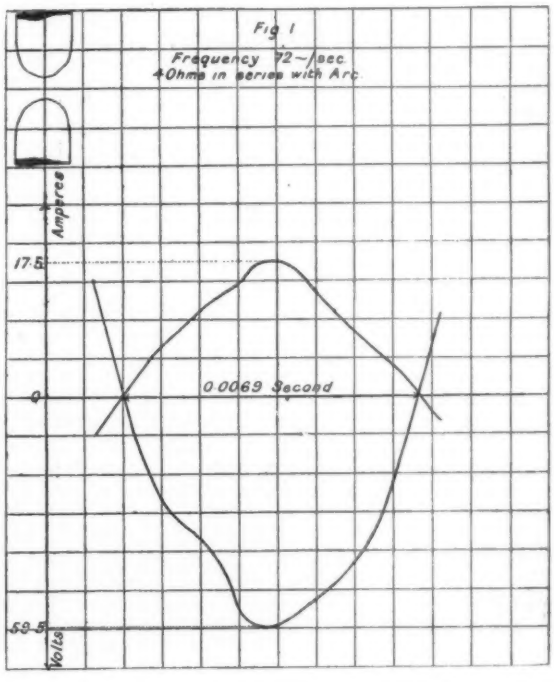
UNDER Dr. Hopkinson's direction I have been carrying out a series of experiments on alternate current arcs, and the note in your issue of the 16th instant has referred us to the very interesting work of M. Blondel on this subject published in *Electricité*. I enclose some curves with notes thereon, which may be of interest as they confirm results already arrived at by M. Blondel.

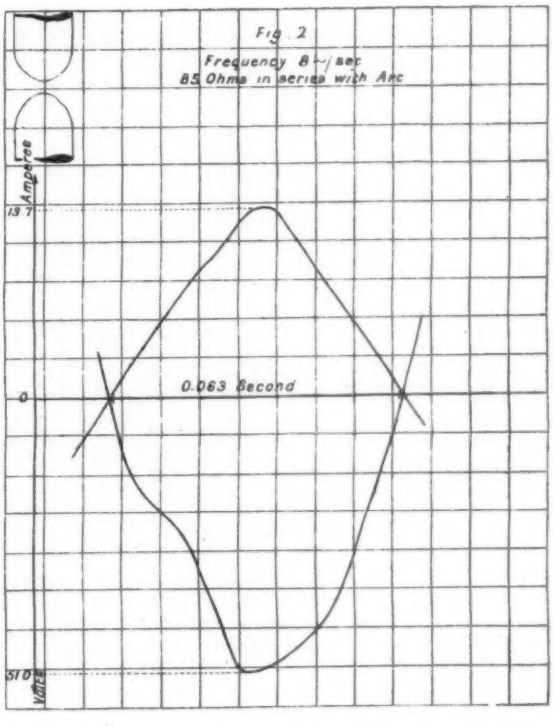
M. Blondel divides alternate current arcs into three classes (see *Electricité* November 17th, 1892) as follows:—

1. Silent arcs.
2. Noisy arcs.
3. Hissing arcs.

Silent arcs.—Our experiments, so far, have been carried out upon this class of arc. The carbons were 13 mm. diameter with soft cores, and were regulated by hand. The arc lamp was placed in series with a non-inductive resistance and a Siemens electro-dynamometer across the terminals of the alternator. The potentials between the carbons, and between the ends of the non-inductive resistance were respectively measured for known epochs of a half period by means of one of Lord Kelvin's quadrant electrometers, and a contact maker, in the manner already described by Dr. Hopkinson in his test of two Westinghouse transformers (see *Electrician* June 24th, 1892). In each experiment readings were taken on the electrometer for one and the same reading on the electro-dynamometer.

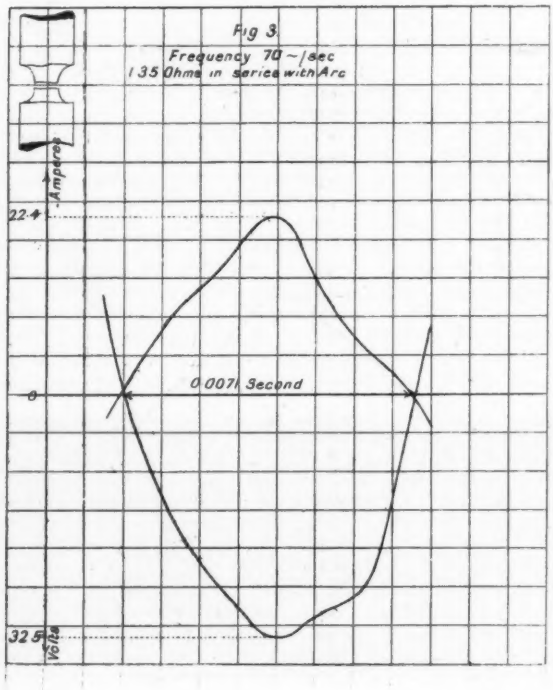
In the accompanying figs. 1 and 2 the potential and current

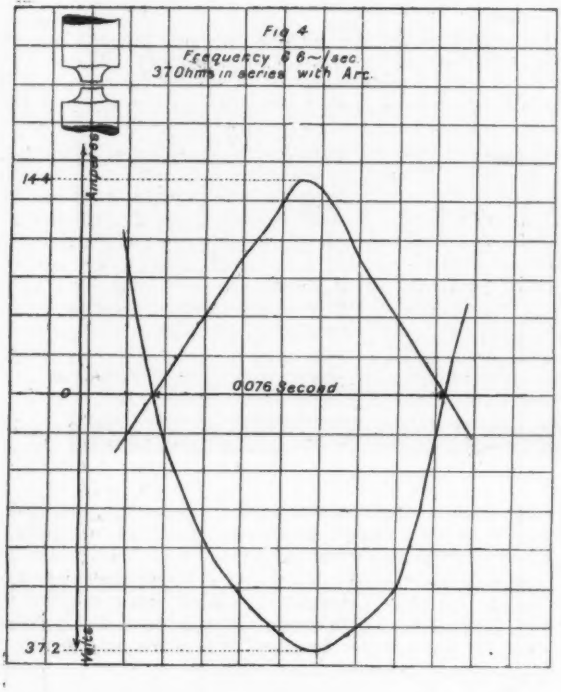




curves are given for a comparatively long arc for frequencies of 72 and 8 complete periods per second. The arc had in each case a distinct violet colour, and the similarity in form of the corresponding curves in the two cases is striking.

In figs. 3 and 4 the curves have been obtained with comparatively short arcs for frequencies of 70 and 6·6 complete periods per second. Here, again, the corresponding





curves in the two cases are similar in form, and further, they agree with those of M. Blondel obtained with a silent arc (see fig. 3 of the *Electricité* paper). This may be due to the alternators having similarly shaped and relatively placed pole-pieces and armature coils. These arcs had not the violet colour observed in the arcs of figs. 1 and 2.

The curves of potential and current in each of the above cases have this feature in common, that they cut the axis at the same point, and that for no finite time does the current remain at zero. From this point of view the arc acts in the same manner as a non-inductive resistance—its conductivity varying with the cross-section of the heated gases between the carbon points—the cross-section varying with the current.

With the low frequencies above mentioned the arc was very trying to the eyesight, on account of the persistence of the image on the retina not being sufficiently great.

Hissing arcs.—In a paper on the theory of alternate currents read before the Institution of Electrical Engineers in 1884, Dr. Hopkinson assumed that "there is in the arc a constant electromotive force always opposed to the current, except when the current ceases, and that then its value is zero"—basing his theory upon conclusions drawn by Joubert. It was this effect which was being sought for in our experiments, and M. Blondel has shown that it can be produced by using a hissing arc, obtained by making the length small, and without self-induction in the circuit, in which case the arc was accompanied by a greenish colour instead of violet (see curves in fig. 4 of the *Electricité* paper). By the introduction of self-induction into the circuit of the hissing arc M. Blondel shows (fig. 5) that the finite time during which the current was previously zero disappears; although the curve shows a marked decrease in the rate of change of the current about the point where it crosses the axis. It is difficult to conceive why the difference between the silent and hissing arcs (each without self-induction in the circuit) should bring about this effect; but it is probable that the *dwell* of the current at each half-period is the cause of the hissing, which, were this true, should diminish in intensity with a decrease of the frequency. M. Blondel appears to have worked with frequencies of 26 and 52.

ELMORE COMPANIES.

THE reports of Elmore's Patent Copper Depositing Company with statement of accounts to June 30th and of Elmore's Wire Manufacturing Company with accounts to October 31st, are issued. The meeting of the Foreign and Colonial Elmore was held last week, and if the French, German and American Companies could be persuaded to issue their reports now, it would be possible to review the condition of all the members of the Elmore group. At the meeting of the Foreign Company it was stated that the French Company was *in extremis*, and that the meeting of the Foreign Company was delayed in order that all the companies might be saved by appearances. To be poor is one thing; but to be poor and to seem poor is apparently a very serious matter to the Elmore Companies. The reports now before us do not succeed in disguising the unpalatable fact that the companies to which they refer certainly are poor, but the current expenditures have been on such a scale as would be calculated to maintain a contrary appearance as long as possible.

The Wire Company's accounts show that the company has a capital issue of £129,506 9s. 8d., and has received £63,717 10s. for premiums in addition. This is what it began business with a little more than two years ago. On October 31st last it had at London Bank and in hand £89 19s. 6d., and at the Leeds Bank an overdraft of £164 11s. 2d., or, balancing the two accounts, a net overdraft of £74 11s. 8d. A very small portion of its capital (£13,000) was invested in land, and upon this there is a mortgage *and interest accrued* of £10,373 5s. 9d. The capital expenditure during the year has been £32,173 11s. 9d. on buildings and plant. To spend this amount, and conduct the other arduous work of the company, has necessitated an expenditure on administration during the year of £4,681 0s. 10d., unless the directors' fees still owing are included in that amount, in which event, £1,168 18s. 6d. needs to be deducted from "expenditure," and called an "incurred liability," of which there are some more (over £6,000) to be added to the capital liability. Of the

assets, the land is mortgaged, and the other items are trifling, except the buildings, plant, and machinery, which stand for £73,456 3s. This appears to be the amount actually expended, and the report tells us that "obstacles" have been met with, and "these obstacles always involve considerable cost for necessary alterations of plant," so that it would doubtless be necessary to make some considerable deduction from the expenditure in order to arrive at the value of the plant as an asset. Under any circumstances, the value is clearly dependent on the company as a going concern, and how long it can be a going concern will be dependent on the amount of working capital which the directors have the pleasure to inform the shareholders "has been provided for." Having set forth plainly the company's financial position, we ought not to omit the important statement that "every difficulty which has arisen has been of a purely mechanical nature, and in no single instance has anything occurred to lessen the directors' faith in the process itself as an electro-metallurgical operation." The importance of faith in electro-metallurgy is apparently almost as great as it was once supposed to be in homœopathy, or is now in healing by mental suasion; but faith, as an element in the production of dividends, has not of late years had much vogue. The position of the shareholders in the Wire Company is such that a respectable dividend on the full capital can only be obtained by a miracle, and it might be well for the directors to intimate to the shareholders the extent of their faith in miracles.

Of all the superfluous Elmores, the Wire Company occupies the superlative position of superfluity. Formed for the purpose of acquiring a license of doubtful value, and paying £111,940 for it, the company was the prime cause of all the subsequent Elmore speculation, because it enabled the parent company to pay a large dividend, and so create that position of apparent prosperity and artificial importance, without which the formation of the later companies would have been impossible. The license was purchased on "faith" in the process, the works have been erected on "faith" in the process, the bank over-draft has doubtless been incurred on "faith" in the process. The shareholders will doubtless eventually conclude that their affairs might have been better looked after by those who possessed a little less faith, a little more common sense, and some idea of what is due to those who subscribe to share capital. Let the shareholders compare the expectations which were held out to them at the last meeting with the report now presented.

Elmore's Patent Copper Depositing Company, the parent concern, has arrived at the respectable and responsible position indicated by a third annual report. We believe the company acquired the process on the understanding that it had been fully proved on a large scale, thoroughly investigated by competent electrical engineers, and had arrived at such a stage as to enable the company to start at once as manufacturers and dividend earners, but the third annual report says that "fresh difficulties have arisen with the fresh experiences entered upon, and consequently the company has been obliged to refuse large orders which might otherwise have been secured," and the third annual profit and loss account shows a balance of £8,566 5s. 6d., *not* on the right side.

Out of a capital of £164,790, this company has invested £60,938 13s. 8d. in land, and has promptly mortgaged the same for (with interest) £41,837 3s. By this means the second largest item on the asset side of the balance-sheet is removed from consideration; buildings, plant, and machinery stand for £48,057 8s. 6d.; patents, &c., £81,321 16s. 4d. is the largest item; stocks-in-trade, £10,177 11s. 10d.; fixtures, furniture, &c., £946 15s. 3d.; cash, £2,094 5s. 8d.; sundry debtors, £3,885 14s. 5d.; and one other item—£11,958 9s.—shares in Wire Company "at cost." Some founders shares in the Wire Company were obtained as part purchase of the license. It would be of interest to the shareholders to learn the basis of the "cost" of the wire shares as they stand in the balance sheet.

It has cost the company £4,024 5s. 9d. in administration expenses during the year in order to earn £772 17s. 3d. on "factory account," which we presume to be the "satisfactory profit" referred to by the directors on "trading account." Other items bring the total payments in profit and loss account up to £10,418 13s. 1d. In the report we see no reference to new capital, but as there is nothing left to mortgage, except the plant and works, we do not see how the company can continue to exist unless new capital is forthcoming, and as to the expenditure of further capital a few words ought to be said.

The majority of the directors on the board are the same as those who have had the management of affairs either since the commencement or for a considerable time. Works on a large scale started on "faith," general expenditure on a lavish scale commensurate with maintenance of appearances, have brought the company to its present position. Let shareholders remember the numerous occasions when they were informed that operations upon a commercial scale were "just about to begin," or had already begun, and compare all those statements and promises with the present report, which, to do it justice, is more moderate than some of its predecessors. Whether this arises from the new element amongst the directorate, or simply by force of adverse circumstances, it is hard to say; but, notwithstanding this moderation, all the hopeful signs are illusory. The difficulties are "mechanical" (the process is semi-mechanical). Lloyd's Committee have signified that Elmore pipes may be used "under the same conditions as ordinary copper pipes." (We presume that the committee would give similar facilities to any productions whatever.) Beyond the delay, &c., "all the expectations have been realised, namely, that the quality," &c., &c. Amongst the expectations were early and large dividends. Their non-arrival is to be accounted for by the "delay," &c., but shareholders should be very careful how they accept assurances that all the other expectations have been realised. Until the products of the company have been introduced on a commercial basis, it is quite impossible to say that the expectations have been realised. The products have not been introduced commercially, and any "assurances" are now as much expressions of "faith" as they were before. There are serious questions before the shareholders, and the sinking of more money is one of them. We have taken the report and the assurances *au serieux*, as we are bound to do for the present. Shareholders may be warned that they have now to look to the "process." It is unlikely that they will be able to shift their burdens on to other shoulders by means of any glowing statements of possible eventualities or new and original discoveries. The Elmore "boom" has been overdone, and it will be some time before the public will listen again to the voice of the Elmore charmer. The shareholders should, therefore, realise that only by commercial success can they reasonably expect to obtain any returns upon their investments. They are dependent upon the "process," and it needs now no technical skill to form an idea of what may be expected. It must be a wonderful process indeed which can pay a dividend on the wasted and misspent hundreds of thousands involved. It must be capable management indeed which can remedy the evils of the incapable management of the past. Even with the best of management the results are still dependent on the process, and our readers know that the Elmore process is not wonderful enough to bring prosperity to companies whose financial condition is so hopelessly bad as those whose reports are before us. Shareholders—and especially original shareholders—may be reluctant to believe that their faith in a "revolution of the copper industry" has been misplaced, though they can see that the only revolution so far is that of the mandrels, which have been so successfully made after years of patience and considerable expenditure of their money! A great responsibility has already been incurred, and care should be taken that it is not rendered greater by the embarking of more capital in unsound and hopeless enterprises.

As we expected, the transfer of the board meetings to Leeds has led to the shareholders meetings being held there also. This will no doubt conduce to smaller numbers and greater harmony, but we hope the shareholders will carefully watch their own interests.

Great Yarmouth Electric Lighting.—A rather noisy meeting of ratepayers was held on 22nd inst., when a resolution protesting against the electric lighting scheme, which would involve an expenditure of £15,000 to £20,000, was passed by an overwhelming majority.

LEGAL.

NATIONAL TELEPHONE COMPANY *v.* GRAFF-BAKER.

High Court of Justice.—Chancery Division.

(Before Mr. Justice Kekewich.)

(*Continued from page* 762.)

THIRD DAY.—DECEMBER 13TH.

Dr. EDWARD HOPKINSON, managing director of the firm of Mather and Platt, Limited, examined by Mr. MOULTON, said he had been requested by the plaintiffs to make an estimate for different methods of working the Leeds electrical tramway, using insulated metallic circuits. In the first method he followed out the line which had been already adopted of using overhead conductors, insulated, and a return partly through the earth and partly through the rails, and partly by an insulated conductor laid in the earth. The second method was with a double overhead conductor, all the conductors being insulated from the earth. This was worked out on a higher potential—600 volts—between the two conductors. The third method was also with all the conductors insulated from the earth, but in that case he took the difference of potential at 300 volts, for the reason that 600 had never been actually sanctioned by the Board of Trade, and it was possible they might take exception to the use of such high tension. The amount of the first tender was £14,251; of the second, £12,698; and the third, £14,665. That in each case included boilers, engines, generator dynamo, cars with the motors upon them, and conductors, but no buildings or builder's work. In his opinion, one of the two systems in which there was no connection to earth, the whole system being insulated, would be the cheapest and most satisfactory in working; because if they had earth connections, making use of the earth for the return, there were various joints in the system, each of which was liable to introduce rust, which would increase in course of time by the oxidation of the joints, and the actual wearing away of the tramlines themselves by the traffic, so that, although in the first instance it might be fairly satisfactory, it would no doubt tend to become less so in course of time.

Cross-examined by Mr. BOUSFIELD: According to his view, the defendants were very foolish not to have adopted the second system. He did not know that the existing regulation of the Board of Trade said that two overhead conductors, near one another, must not have a difference of potential between them of more than 300 volts; even if that were so, he did not think his second estimate would be valueless, because if the matter were put before the Board of Trade in a proper light, he thought they would consider it reasonable. The reduction in the second estimate was partly due to the fact that with a double potential, half the weight of copper only would be used. The Bessbrook and Newry tramway, which was carried out by Messrs. Mather and Platt, was a single conductor line, being so constructed because in that case it was desirable for many reasons to place the conductors approximately to the plane of the rails carrying the cars. There were in that case certain advantages of simplicity, as the single conductor which did not extend to cases where there was either a conduit or an overhead conductor. Witness superintended the construction of the Giant's Causeway line, which was put down under the supervision of Sir William Siemens, but why that was made a single conductor line he could not say. The single conductor was adopted in the City and South London Electric Railway for the same reason that he had mentioned in the case of the Bessbrook and Newry line. There it was desirable to have the conductor in the plane of the rails.

But you have got one conductor between the rails, have you not?—Yes.

It would have been just as easy to have two conductors between the rails, so as to have the return independent of the rail, would it not?—No, it would not. There is great difficulty at the points and crossings.

That is where I suggest the difficulty comes in. Where you have points and crossings, you do get a difficulty if you have a complicated system with two conductors instead of one; that is so, is it not?—In the case of the conductors being in the plane of the rails; not otherwise.

You have to have certain breaks and so on, whether they are in the plane of the rails or above the plane?—Yes.

Re-examined by Mr. MOULTON: Do these difficulties with regard to points and crossings exist where you do not put the conductors in the plane of the rails?—I should not like to say definitely with regard to the conduit system, because I have little experience of that, but I do not think they exist in the case of an overhead system.

Dr. JOHN HOPKINSON, re-called, said on the last occasion upon which he saw the Leeds tramway, he carefully observed the cars as they ran on the rails in broad daylight, and in every case he could see sparks between the wheels and the rails.

Sir FREDERICK JOSEPH BRAMWELL, examined by Sir RICHARD WEBSTER, said he had been acquainted with the working of the telephone ever since its introduction into England. Throughout the United Kingdom, so far as his knowledge extended, it was practically universal, except on long trunk lines, to use the single-wire system for telephonic purposes. Apart to special breakdowns, that system had worked satisfactorily; it was the commercial system of the present day. He went down to Leeds with Lord Kelvin to judge personally of the extent of the disturbance. Listening from the Central Exchange in Commercial Buildings the noise was extremely irritating or annoying, or both, with the result that quite half the words were lost. He would not care to hire a telephone, and would not become a subscriber at all, if that was to be the condition under which he was to carry on his messages. He knew the system upon which the defendants worked their tramway, and it appeared to him that, with a single wire, and a return partly by the rails and partly by an intermediate wire, which was not insulated, and partly by the earth itself, they were liable to have the effects which had been spoken of. He thought the variation in the contacts between the trolley and the overhead wire might be a cause of variation in the resistance, which would be a cause of disturbances. The sparking at the wheels of which Dr. Hopkinson had spoken was undoubted evidence that there was a variation in the degree of contact between the rails and the wheels. He had himself seen similar sparking in the Giant's Causeway line. He saw and reported upon the Northfleet electric tramway.

Mr. BOUSFIELD objected that Sir Richard Webster was putting another alternative of a wholly different character from those which had been presented to his Lordship. The Northfleet tramway was worked upon quite different principles from either Vevey, Buda Pesth, or Portrush, or any of the others so far mentioned, and they had had no notice whatever of it. He might tell his learned friend that he should produce evidence that that line had been entirely abandoned, and he asked was it worth while to press it? If it was to be pressed, he should formally object on the ground that they had had no notice.

Sir RICHARD WEBSTER said when the evidence came they would judge of it; but with regard to the question of notice, no notice of any kind was required. The defendants were suggesting, by the way they were conducting their case, that theirs was the only system. There was no question of giving notice of other systems, and this was merely an illustration of another method of working exactly similar in many respects to Buda Pesth, and was actually within a few miles of London. He submitted that it could not be excluded in any way.

Mr. BOUSFIELD drew his Lordship's attention to the statement of claim, the pleading being: "The electric disturbance caused by the defendant's system can be readily prevented by the adoption by the defendant of a different method of completing the electric circuit from the defendant's cars to the generating station." That, so far as his recollection went, was the only suggestion in the pleadings that they ought to have done something different from what they had done.

Mr. JUSTICE KEKEWICH: It does not mean that that is the only thing.

Mr. BOUSFIELD: Paragraph 3 of the particulars says: "One different method of completing the electric circuit from the defendant's cars to the generating station, in the doing of which, as alleged in the 9th paragraph, electrical disturbance is caused by the defendants, would be by using two insulated conductors, one taking the current from the generating station to the car, and the other from the car to the generating station. Another method would be by providing better means of contact between the insulated conductor and the trolley, or its equivalent, and between the car and the rails." The defendant came there to meet this, that the double conductor system, as specified there, is the alternative that we ought to have adopted, or if we did not do that, we ought, by providing better contacts between the conductor and the car, and the car and the rails, in that way obviate the disturbances. I submit that that is the issue. Our witnesses have, of course, gone fully into this double conductor system, and we are prepared to lay before your Lordship evidence that that is an impracticable system. My friend has already introduced two, and now he proposes to introduce a third, which I happen to know is wholly different from the others that have been introduced.

Sir RICHARD WEBSTER: This objection really cannot be seriously pressed.

Mr. JUSTICE KEKEWICH: I need not trouble you. This, to my mind, is an addition to the instances which frequently come before me of the inapplicability of the present system of particulars and interrogatories to actions of this character, and other actions of a similar nature, in the Chancery Division. It is almost impossible, as far as I can see, to logically apply the doctrine of particulars to such a statement as this. What paragraph 9 says is this: "If you had obtained your own result by a different method you would not have interfered with us." How many methods there may be the plaintiffs do not suggest, and it is extremely hard to put upon them the necessity of suggesting at any particular stage of the action what other methods there might be; you ought to have done it differently, is what they say, and they ought not to be called on, and cannot be properly called upon, to supply once for all what different methods might possibly be adopted. But when I come to the order, which I dare say was not a consent order—it is not a consent order in form, but it is obviously an order that was not of a very hostile character—it says: "It is ordered that the plaintiffs do deliver to the defendants by their solicitors particulars in writing of the different methods." What paragraph 9 says is "a different method," not at all suggesting that there is one, and only one, or two, or only two. It would be extremely difficult to have drawn an order which would have forced particulars. I think the order fails to achieve the result, but it produced particulars in which the plaintiffs say one different method is so and so, and another method is so and so. Ought I to assume from that, that that is intended to be exhaustive? It seems to me that is no more exhaustive than the statement of a different method in the statement of claim. The fault is there being any particulars in the matter, to my mind; but, at any rate, unless Mr. Bousfield can allege (and as to this, of course, I will take his word), that he is so surprised, that he ought to have an opportunity of considering further evidence:—

Mr. BOUSFIELD: I think we shall be able to meet the matter when it comes, but I thought we were diminishing the bulk of the enquiry by getting the particulars.

WITNESS, resuming, said there were no overhead wires in the Northfield line, and nothing visible on the surface of the road other than an arrangement in connection with one of the rails. The tramway was one of 3 feet gauge; it was a continuation of a horse tramway from Gravesend to Northfleet, and extended from the termination of that tramway to near the Northfleet station on the South Eastern Railway. The road presented a variety of gradients and curves and difficulties of that kind, and he had no doubt it had been selected in order to show the ability of the system in dealing with the various exigencies of tramway traffic. Witness read from his report the following descriptive passage: "Along the high road is laid that which, on a mere casual view, looks like an ordinary narrow-gauge tramway line for horse traction, that is to say there appears to be nothing but the two grooved rails. On closer inspection, however, it turns out that the southern rail is composed of two distinct rails, placed so as to leave between them not a mere groove for the flange of the wheel as there is in the northern rail, but a complete gash or longitudinal opening leading into a longitudinal chamber below that rail." The width of the slot in that case was $\frac{7}{8}$ths of an inch. He had not the slightest doubt that the slot in the Buda Pesth system could be reduced to three-quarters of an inch, as Lord Kelvin had said. The Buda Pesth rail, according to the section that he saw, prepared by Dr. Hopkinson, appeared to have both conductors on one pendant bar that worked in the slot. Obviously, if there was any need to make the slot as narrow as possible, it would be perfectly feasible by merely lengthening the pendant bar to keep the one conductor in one portion of its length, and the other conductor in the other portion of its length. With regard to what had been suggested as to the insulation being rubbed, he did not for a moment agree, for the simple reason that not only was the whole of the pendant bar the conductor of electricity, but each end of it might be simply an inner piece of steel having nothing to do with the electricity which would be somewhat wider than the conducter, and would thereby fend it off from any possibility of rubbing against the slot. There was no necessity for the slot in an electrical system to be larger than in a cable system; on the contrary, there was obviously a reason for it to be less, because in a cable tramway the whole power of the rope to draw the tramway had to be communicated from below the surface to above the surface by means of the implement that went through the slot, whereas in the electrical case the only thing they had communicated was the electric current. In his opinion there was no reason, either from a practical or a scientific point of view, why an electric tramway with a slot in one of the rails to allow the communication to be made, should offer more obstruction in the road than any other tramways. The Northfleet system had an insulated metallic return, and was therefore altogether metallic. The Northfleet mode of applying the current was a peculiar one, called the Series system. He could not imagine any practical difficulty in applying such a system as the Vevey system to crossings. One thing seemed to him conclusive as showing that it could be done. The wheels of the tramcars on the defendant's system were the means which made the electric connection between the motors on the cars and the rails, and the intermediate wire; and whenever they came to one of those complicated places, such as was suggested at Boar Lane Leeds, they were compelled to have provision for those wheels to pass, that was to say, if a passing was to take place. He could not see any greater difficulty in making a provision for the positive conductor to pass, than in making provision for the negative conductor to pass. If they could do the one they could the other. There was no difficulty, except from the point of view of expense, in working electric tramways by means of secondary batteries. Tramways had been working at Birmingham for some time with secondary batteries, and they were largely used for electric launches.

After the luncheon interval, Sir FREDERICK BRAMWELL said on reflection he was not quite clear whether the sparking that he saw on the Giant's Causeway Railway came from the wheels or from some brushes which completed the circuit.

Cross-examined by Mr. BOUSFIELD: In any case, it is not clear that the sparking, as sparking, would cause what has been complained of?—I do not think that it is clear, but I should take it as an undoubted indication of very rapid variations in the current.

They are more or less rhythmical, are they not? The sort of noise which is heard approximates to a musical note?—No; I should hardly have thought so. It varies a very great deal sometimes. The term I should apply to it would be a roar, and that is hardly the term I should apply to a musical note.

I suppose you would agree with the last witness that if, as a matter of fact, when you cut out the trolley connection, and cut the wheel and rail connection, supplying their place with non-conductors, there is substantially the same noise heard, it could not be attributable to that cause?—That goes to prove that the noise will exist without that cause; I should think that cause must contribute, but that would certainly prove that it would exist without.

It is present to your mind that all four wheels of the car are connected to the rail?—I believe so. There are two motors, one to each pair of wheels, and I presume advantage is taken of all four wheels to make a connection with the rails.

So that an interruption to one would produce a variation in that part of the current which flows through that particular wheel?—I do not think you could get sparking without an appreciable variation.

Not a variation in the whole current, but only that portion which flows through that particular contact?—If only one wheel out of the four, that would be so, no doubt.

Let me ask you to look at a certain map of water pipes which I have here. First of all, I will put this general question: If by connection with a system of water pipes lying parallel with the tram rails, and near to them you make that system a part of your telephone circuit, then you would get a very considerable increase of disturbances from the variation of the tram current? An increase as compared with a general use of earth instead of a concentration of current along water pipes close to the tramway?—I should think you would, unless you had the precaution to insulate the conductors of your tramway pretty close together.

The condition of things, therefore, is probably very much aggravated by the fact that the water pipe system is used as earth by the plaintiffs?—Yes, it may or may not be; it is quite possible that it may be, but I have made no experiments to see whether that is so. In the first place, I do not know whether it is used as earth; in the second place, I do not know its position in relation to the tramway, and in the third place, I do not know what the effect will be if we are to earth in another manner.

COUNSEL, having drawn witness's attention to a map of the water pipes in Leeds, said: Then the result of that would be to keep in a large part of the earth return in the water pipes?—I should have thought it would be the other way, if you are speaking of leakage, but if you are speaking of induction——

I am not for the moment; what I mean is the return current of the telephone would under these circumstances chiefly go through the water pipe with a certain amount of leakage into the earth; and, of course, an earth break at the points I have indicated?—Yes, I should imagine so. I, for one, do not believe in any return current. I believe we are all pumping out of, and drawing into a common reservoir.

That is only a mode of speaking—it does not affect the conclusions?—No, it does not.

Then, assuming that that water pipe all the way along from the exchange to that point in the Roundhay Road, nearly two miles, was within 3 or 4 feet of the tramway rail and the tramway conductor, you would expect, would you not, a very considerable negative effect to be exercised in that circuit of which the water pipe forms part?—I should think so, but how much I do not know, and I should not attempt to give an opinion in the absence of direct experiment.

The plaintiffs themselves use the double system for long trunk lines. I suppose there are a great many other cases where they use it for short circuits, or comparatively short circuits, where there is a liability to disturbance?—I should not put it in that way. I should put it that where they have a number of wires grouped in one cable, that then it is desirable there should be the double metallic circuit.

Is it not the fact that wherever, owing to any cause, there is a liability to disturbance by other electrical influences, the plaintiffs fall back on the system of metallic return?—No; I do not think that I can say yes to your question as put, because you say, "other electrical disturbances," whereas in the case of the bunched cables it is their own electrical disturbances.

I was taking first of all earth currents which exist?—I do not remember a case of the double metallic on account of earth currents.

On long lines you do very often get traces of an earth current, do you not?—I am not sufficiently practically acquainted with the working of the telephone on a large scale, but I should not have thought that an earth current would have affected an instrument like the telephone—I mean an earth current in the ordinary sense of the word. A rapidly alternating current in the earth is of course a very different thing.

We know that the telegraph current does affect the telephone?—Yes.

But I rather gathered that on any long distance line, whether it runs near a telegraph line or not, the plaintiffs have found it necessary to duplicate their wires?—I do not know that to be so.

Do you know of any case of a long distance line which they have not duplicated their wires?—No; but on the other hand, I do not know whether there is a long distance line which does not go near some telegraph wire, therefore I cannot answer you.

Then, at all events, the doubling would get rid of the disturbance of the telegraphs?—Yes.

Then I think generally in any case where there is disturbance from some external influence, whether of other wires, or telegraph wires, or whatever it may be, the plaintiffs do fall back on the system of doubling their wires with a metallic return?—I am not connected with the direction of the company, and I therefore cannot answer you; but I think I may answer you safely in this way, that wherever they find it desirable to have the double wires they use them. That, I think, I may safely answer you, and perhaps they possibly avoid expense to them, and something more than expense. I am thinking of the great snowstorm of four or five years ago, and what did happen then, and what would happen now, to overhead wires, if they were doubled.

You mean the more wires the more snow upon them?—Yes.

That is again avoided by doubling, and putting in cables collecting the bunch of wires?—Underground, I do not know the present condition of the law, but I do not think we have any general power to break up the roads to go underground. The Post Office have, of course.

I take it is considered by scientific men to be of great importance that the overhead system should not be allowed to increase, and the underground cable system should, as far as possible, be adopted?—I do not know about scientific men, but there are other things to be considered besides pure science. You have to work an undertaking so that it will pay.

Perhaps, as you have mentioned that, you can tell us what the dividend of the National Company has been?—I ought to be able to, because I am a somewhat considerable shareholder, and, perhaps, I ought to have mentioned that before; when I say considerable, I mean considerable for a man of my means. I really do not remember what the dividend is.

It pays very handsomely at present?—I am glad to say it does.

And it might still pay handsomely if in certain disturbed places they doubled their wires?—I do not know. If you make a large capital expenditure and get no more return, my humble arithmetic points to a reduced dividend.

I believe the present dividend is somewhere about 12 per cent.

Sir RICHARD WEBSTER: Five or 6 per cent., I am told.

WITNESS: All I know is the shares are only just at par—the £5 shares. I happened to be reading the paper while the Court was adjourned, and I happened to see the £5 have fallen ⅛ths to 5⅛th, which does not look like a state of bloated affluence.

You say the earth return system has worked satisfactorily?—Yes, in so far as it makes a commercial implement for which I am quite content to pay, and continue to pay, £20 a year.

But, as a matter of fact, that commercial implement, even as you know it and use it in London, with the earth return, is a very imperfect implement indeed, is it not?—It is a very imperfect one as compared with one with a complete metallic return, where you would get absolute silence, but you may buy anything too dear, and whether you buy that silence too dear is, I think, extremely likely. The thing as at present arranged works, and works commercially.

It works, but——?—You may be irritated or annoyed, or both.

And sometimes it even amounts, as things are in London, to a practical stoppage of communication?—Not to my knowledge. I know of a practical stoppage of communication, because the business is so large that you cannot get switched on, but when you once get switched on I do not know, as you would suggest, that the interruption is such as to be a practical stoppage of communication.

With regard to the Northfleet tramway, had you yourself anything to do with that?—Nothing except to examine it, and report upon it at the request of the syndicate that owned it.

I suppose you know, now, that the electric working has been abandoned?—I did not know it, but I am not surprised to hear it. It is in a most remote place, away from any possible traffic or anything of that kind, as it appeared to me. I have heard of a very much larger development of that system at Rome.

Perhaps you have heard, also, that the Rome one has been abandoned?—No, I have not.

What is more to the point will be this: Can you tell us of any case besides the two that have been mentioned of Vevey and Buda Pesth, where there is a tramway worked on the double-conductor system, and in successful working?—No, and I do not know either of these of my own knowledge.

I put this to you about the Northfleet tramway. I think the great difficulty they met with on that tramway was the constant catching of what I call the hanger; I believe it is more correctly called the knife—which went down into the slot; the constant catching of that and the difficulty of making the proper electrical connections through that slot?—Not to my knowledge. I cannot help thinking that you are mixing up two things, the one the pendant piece which went through the slot, the other the arrow, I think, was the technical name they gave it. There were two pendant pieces, and the arrows which hung to these and which made the connection between one of the conductors by means of what are called spring jacks, and the difficulty, I think you will find, was making the connection between the arrow and the spring jacks, and I do not think you will find it was any difficulty in connection with the pendant pieces which connected the carriage to the arrow.

You have heard of the difficulty having arisen?—I have not; perhaps incautiously I took it from you that there was a difficulty, and that you were putting it to me.

You rather assume that is the place where the difficulty might arise?—Yes, I can imagine it arising there, for that involved making the contacts every 21 feet, I think it was. I cannot imagine any difficulty arising in a mere pendant piece of metal, which was also the conductor of electricity into the car.

I daresay you will not be surprised to learn that you have pointed out the very difficulty which led to the abandonment of that system?—It was clearly the tender part of the system, and therefore I thought you were confounding it with that which to my judgment could not be a tender part of the system. The gist of my evidence with regard to the Northfleet tramway is that a ⅛ths slot is wide enough for an electrical tramway; that is all I care about in the Northfleet tramway.

That was practically a single conductor system, was it not?—I really do not know. I think I see what you mean. I do not know what is a single conductor system and what is a double one; that is to say, if I come out and home parallel, whether that is a single conductor bent round, or whether it is a double conductor. It is, of course, a mere matter of words.

There was practically a complete circle forming the circuit, a dynamo at one point?—Yes.

All that you had to do was to get a car in at some point, so that you had not to deal with the problem of conductors, each of which had to be connected to the two poles of the car?—Quite right. It was the series system, and the whole current passed through every car.

Then only a single conductor passed through the slot; the knife only carried one?—It was a curious arrangement. One side of it was connected to the one conductor at its left hand, its trailing end, and the other side with the forward conductor at its right hand, or leading end. In that way the car became for the time a portion of the line itself. It had to make two contacts, but with one and the same conductor, according to my recollection.

On the knife as employed at Buda Pesth there is a chance of two opposite potentials which might communicate with one another, whereas at Northfleet that was not the case?—That is so.

(To be continued.)

ST. PANCRAS ELECTRIC LIGHT STATION.

MR. THOMAS ECCLESTON GIBB, the Vestry Clerk, has presented a most excellent and exhaustive report on the general and financial working of the central station.

The following is a statement of the total cost of the installation, including the estimated cost of works not yet completed, and marked below with an asterisk:—

	£ s. d.	£ s. d.
Site.—Paid for freehold site, including houses in Longford Street, reserved for extensions	10,000 0 0	
Interest on purchase money	21 7 5	
Compensation for subsidiary interests and loss of rent	292 18 6	
Law Charges	169 5 10	
Clearing the site	40 17 6	
		10,524 9 3
Cost of obtaining loans		145 10 5
Station and Sub-Station.—Buildings, £7,905 2s. 4d.; boilers, pumps, &c., £4,617 10s. 10d.; engines and dynamos, £18,180 7s. 5d.; switchboards, £1,370 5s. 10d.; batteries, £2,961 6s 11d.		35,034 13 4
Street Trenches and Electrical Conductors.—Trenches, £13,167 10s. 8d.; conductors, £17,906 15s. 1d.; * extensions nearly completed, exclusive of those for public lighting, £3,820		34,894 5 9
Instruments, Meters for Hire, &c.—Electrical instruments, £284 16s. 3d.; general machinery, tools, &c., £190 7s. 5d.; office and committee room fixtures, &c., £167 0s. 9d.; meters for hire, switches, fuses, &c., £1,181 13s. 8d.; general stores, £931 10s. 4d....		2,755 8 5
Public Lighting.—† Tottenham Court Road and part of Euston Road, £1,532 2s. 10d.; * Euston Road to King's Cross, £1,400; * Euston Road to "Brecknock," Camden Road, £4,750		7,682 2 10
Miscellaneous.—Fees to Dr. Hopkinson and Mr. Preece for reporting on Prof. Robinson's scheme, committee's expenses, solicitor's charges, &c.		457 2 6
		£91,493 12 6

SUMMARY OF RECEIPTS AND EXPENDITURE.

Capital Account for Installation.

RECEIPTS.

	£ s. d.
London County Council (loan)	10,000 0 0
Prudential Assurance Company (loan)...	60,000 0 0
Rents of reserved portion of site—Longford Street houses, £519 0s. 2d.; *less* repairs, rates, taxes, insurance, &c., £126 8s. 8d.	392 11 6
National Bank, temporary advances	13,797 1 1
Balance due on completion of works in hand ...	7,303 19 11
	£91,493 12 6

EXPENDITURE.

	£ s. d.
Site	10,524 9 3
Cost of obtaining loans	145 10 5
Station and sub-station	35,034 13 4
Street trenches and conductors	34,894 5 9
Instruments, &c.	2,755 8 5
Public lighting	7,682 2 10
Miscellaneous	457 2 6
	£91,493 12 6

Some remarks are necessary with reference to a few of the items in the above statement:—

(*a*) The land reserved for extension of works, and upon which the Longford Street houses stand, is capable of accommodating sufficient plant whereby the present output of current may be more than doubled.

(*b*) The total expenditure for street trenches and conductors, including the extensions in hand, is £34,894 5s. 9d. The original expenditure contemplated provision for current equal to 25,000 16-C.P. lamps, and 90 arc lamps, although the machinery was designed for only 10,000 16-C.P. lamps, and 90 arc lamps. This was necessary, as it could not be foreseen where the current would be taken up. Since we commenced to supply, it has been necessary to extend still further the original provision to meet demands in places not included in the scheduled area, so that now we have provision for more than 30,000 16-C.P. lamps, as well as the 90 arc lamps. The result of this is that at present nearly two-thirds of the capital expended on trenches and conductors, say £20,000, is lying idle, and must continue to do so

* The three items marked * amounting in the total to £9,970, represent estimates for extensions, a large proportion of which are already completed and measured up. The whole of the works will, no doubt, be carried to completion for a sum less than the estimates by from £400 to £600.

† Mains not included.

until further generating plant is put down at the station. The arc lamp plant will be fully charged as soon as the lamps now being erected are put in lighting, so that the arc lighting plant also must be extended before any * more public lighting can be undertaken.

(*c*) The amount expended for meters, switches, and fuses is £1,181 13s. 8d. Of this sum about £1,000 is for meters, which are lent on hire, and which are a distinct source of revenue to the vestry.

(*d*) The amount representing the value of general stores is large. Certain articles of stock representing nearly half the total of £931 10s. 4d., must be idle for the present, owing to a decision of the Board of Trade that the mains for public lighting should be kept distinct from those for private supply. This is not a dead loss as the material can be utilised on further extensions.

(*e*) The extension of public lighting to King's Cross and the Brecknock will add but little to the expenses hitherto incurred for lighting Tottenham Court Road and part of Euston Road, as the plant which has had to be worked for a portion will be sufficient for the whole.

(*f*) The expenditure upon public lighting includes the cost of constructing the new street rests in Tottenham Court Road and other places where arc lamps have been erected. These rests are looked upon as a general public convenience, and might be considered a fair charge on the general rate.

(*g*) In the summary of receipts and expenditure, the amount shown as a temporary advance from the National Bank represents only that part of the total sum advanced by the Bank, which is attributable to capital expenditure. The item of £7,303 19s. 11d., the balance of the account is not yet due, although the works are in hand, and it represents part of a larger sum upon which advances to the extent of £2,666 0s. 1d. have been made. The advantage which the Vestry have had through obtaining this temporary accommodation from the Bank, instead of obtaining a further loan earlier, is that only 3 per cent. interest has been paid upon the money instead of 3½ charged by the County Council and the Prudential Assurance Company, and there have been no instalments to pay off.

First Year's Working.

In giving particulars of the first year's working, it must be remembered that the officers and servants were appointed in September, and in one or two cases earlier, and that from that date the installation was worked for the purposes of testing, &c. There was other expenditure also for coals and other things, from which no remunerative return could be derived.

The following statement shows the working expenses from the commencement down to November 8th, 1892, on which day the first year ended from the date the supply of current was commenced. Some of the expenditure, therefore, dates back for a year and a-half, and even longer.

STATEMENT OF EXPENDITURE TO NOVEMBER 8TH, 1892.

	£	s.	d.
Coals...	2,306	15	2
Water, oil, waste, &c.	354	17	1
Salaries	689	6	11
Wages...	2,301	17	4
Printing and stationery	187	7	10
Advertisements	35	3	9
Electrical papers for committee	18	16	10
Committee's expenses on view	20	0	10
Repairs	171	15	1
Insurance	79	12	9
Cost of meter connections (charged to consumers)	137	7	11
Licenses	19	11	5
Carbons for arc lighting	110	11	7
Other charges	119	1	1
	£6,552	5	7

Summary of Receipts and Expenditure on Working Account.

RECEIPTS.

	£	s.	d.
Current supplied from November 9th, 1891, to September 30th, 1892	4,691	2	5
Current supplied during October, 1892	1,023	5	2
Current supplied for eight days in November (estimated)	290	0	4
Current for public lighting	1,411	17	9
Current for public urinal	39	15	9
Works for private consumers—Meter connections	148	15	4
Sundry small receipts	15	8	10
	£7,620	5	7

EXPENDITURE.

	£	s.	d.
As per above statement	6,552	5	7
Balance towards payment of interest and repayment of loans	1,068	0	0
	£7,620	5	7

* Two dynamos have been erected for the 90 arc lamps—one being kept as a stand-by in case of accident. If two more machines were erected, the one stand-by would still cover any risk, and 270 arc lamps could then be supplied. These 270 arc lamps would be sufficient to displace the whole of the 1,200 gas lamps within the area, which can be economically served from the present station.

With regard to the foregoing statements on the first year's working, I desire to make a few observations:—

(*a*) It has been already pointed out that the expenditure is for more than a year. It may also be said that the expenditure has been upon a plant which for a large part of the time has not been doing a tithe of the work it was capable of doing. During last winter we had few customers, and during the summer but little light was required.

(*b*) In the above summary the receipts for current from November 9th, 1891, to September 30th, 1892, was only £4,691 3s. 5d., whereas during the month of October, when the plant was still not in full use, the receipts amounted to £1,023 5s. 2d. From this it may be expected that the total annual income from this source will be, without any extension of plant, &c., at least *£10,000 a year, and this is exclusive of the value of current used for public lighting, which will add another £3,000 or so.

(*c*) With reference to the balance shown of receipts over expenditure of £1,068, it will be noticed that this is but a small contribution towards the amount charged for interest and instalments of principal. This point will be referred to in the cash statement later on. It may also be observed that nothing has been allowed for depreciation. The reason for this is, that the six months' maintenance under the contracts has but recently expired, and some of the plant has been scarcely used as yet. No large provision for depreciation ever will be necessary, because [electric lighting plant must be kept in perfect condition by continuous repairs and renewals in detail.

Cash Statement—Capital Account.

RECEIPTS.

	£	s.	d.
London County Council ...	10,000	0	0
Prudential Assurance Company	60,000	0	0
Rents	392	11	6
† Loan required to balance	21,854	3	4
	£92,246	14	10

EXPENDITURE.

	£	s.	d.
Preliminary expenses	753	2	4
Cost of installation and extensions in hand	91,493	12	6
	£92,246	14	10

After speaking of possible economies that may be effected, Mr. Gibb says that there is one source of profit that has not developed as rapidly as was expected, that is, the use of electricity for motive power. It is a subject to which the chairman of the committee, as is well known, has devoted much time and attention, and is one upon which I laid much stress in my report to the vestry, made in 1882—10 years ago. When recently it was determined to reduce the price of current for day supply it was naturally expected that a considerable demand for motive power would arise, but it is to be regretted that as yet the advantages offered are not realised by the many small manufacturers to whom this would certainly be a boon. Recently our resident engineer, Mr. Baron, has developed a suggestion of the chairman's for the provision of a "day switch," which, it is hoped, will give an impetus to the demand for power, as well as for lighting basements and places where the constant use of gas is injurious.

* This is a low estimate, as experience proves that each 16 candle-power lamp installed will yield an income of £1 per annum at 6d. per unit; and as 13,000 lamps installed represents in this district 10,000 simultaneously at work, the income may be expected to reach £13,000, or even more, per annum, and this without taking any account of the consumption for motive power during the times of light load.

† The actual sum due to the National Bank, as shown by the pass book of the electricity department, is only £19,300 1s. 11d., but the balance of £21,854 3s. 4d. includes sums due, and to become due, for extensions in hand, but not completed.

The Paris and New York Telegraph Company.—The *Daily News* Paris correspondent telegraphs: The Tribunal of Commerce has given judgment in the Paris and New York Telegraph Company affair. The suit on which the Tribunal decided was brought by a certain set of the shareholders. The company is split up into two sets, one of which contested the validity of votes taken at general meetings that were called for May 31st and July 12th in the present year. The Tribunal has so far given judgment in their favour as to name provisional manager M. Lougarré, who is ordered by it to convene another general meeting of the shareholders within the shortest delay that the statutes admit of. This meeting will be empowered to elect a board of directors. But on no other point is the Tribunal favourable to the plaintiffs. They and the defendants are to pay the costs they have respectively incurred.

NOTES.

For the New Year.—To our readers, all the world over, we wish a happy and prosperous New Year.

Gilbert's "De Magnete."—There is an announcement that a reliable translation of Dr. Gilbert's "De Magnete" is shortly to be published in New York. Some time ago, the "Gilbert Club" was formed, says *Engineering*, with several purposes, one of which was to prepare a translation of this work and to publish a number of copies. Dr. Silvanus Thompson at the time, had a good deal to say on the matter. Our contemporary believes that one of the intended features of the work was that each chapter of the translation was to commence with a facsimile reproduction of the great initial letter of the original. As a large number of these are varying designs of the letter "Q," the delay may be caused by the difficulty of finding English equivalents commencing in the same way. Meantime, Mr. Mottelay, of New York, who appears to be familiar with more editions of "De Magnete" than were dreamed of in the philosophy of the Gilbert Club, has completed and is publishing his translation, which will render the further struggles of Dr. Thompson with the letter "Q" wholly unnecessary. But at this, says our contemporary, for some surprising reason, Dr. Thompson gets very angry, and calls the firm of eminent New York publishers, producing the book for Mr. Mottelay, scurrilous names; threatens to ignore—and this is really too severe—the book when it appears, instead of welcoming Mr. Mottelay's valuable translation; abandoning his search after English equivalents with "Q," and returning their guineas to those hopeful subscribers who have paid in advance for the still invisible "De Magnete" of the Gilbert Club. Several letters on the subject have been appearing in the columns of another London contemporary. In one letter Mr. James Dredge criticises a communication written for the same journal from the pen of Dr. Thompson, and he denies the accuracy and condemns the bad taste of Dr. Thompson's statement. He also considers that the only conceivable reason for the emotion on the part of the professor is to make the "Gilbert Club's" pretensions even more ridiculous. Mr. Mottelay had interviewed Mr. Dredge, stating that he was not desirous of interfering with the vague intentions of the Club, but he was also very reluctant to allow the "De Magnete" to be treated unjustly by being brought out by someone having very little knowledge on the subject. Mr. Dredge asks when did Prof. Thompson possess an international copyright in "De Magnete"? He states that he is primarily responsible for Mr. Mottelay's proposed publication. Mr. M. F. O'Reilly, D.Sc.Lond., of Tooting College, writes to the same contempory in a strain similar to Mr. Dredge, but we fancy that Dr. Thompson will not easily own himself beaten.

Secondary Batteries in Central Stations.—The use of batteries in central stations seems to be now exciting special attention in America. No one can deny, says *Industries*, "the great value of batteries in small stations, or at the beginning of a larger undertaking, and we wish Mr. Crompton every success in his endeavours to get batteries taken up seriously in the United States. Where we disagree with established notions on the subject is as to their use in alternating current work. Mr. Mordey has, as is well known, studied batteries for some time in the sort of way a naturalist studies vermin. The first thing he found out was that "the great advantage of alternating currents is that people cannot put batteries on." After further investigation he found that "the great difficulty with cells is that they are not all equally bad." Still further observation has led him to admit that "batteries must have strong constitutions to stand the treatment of their specialists." Without venturing to contradict Mr. Mordey on the second and third points, exception may be taken to his first statement. As has often been pointed out in this journal batteries are just as easily applied to alternating systems as to direct. All that is needed is a direct-current machine which can be employed either as a generator or a motor. Some day—in ten years let us say—people will realise that there is nothing in the nature of alternating currents which necessitates 2,000 volts and continuously-running steam engines, and that batteries do not always entail building one side of the station entirely of switches and cell connections."

Electric Lighting of Paris Slaughter-Houses.—Electrical installations are being slowly extended in Paris. We have now to mention the electric lighting of the slaughter-houses, which has just been decided upon by the Municipal Council. Permission for 15 years has just been granted to the Société d'Eclairage et de Force pér l'Electricité, to which a sector has already been granted, comprising the district of La Villette. The lighting of the slaughter-houses will be effected by means of 40 10-candle incandescence lamps, 237 16-candles, 18 6-ampère arc lamps, and 73 8-ampère arc lamps. In the cattle market will be installed 268 16-candle incandescence lamps, 26 10-candle incandescence lamps, and 51 8-ampère arc lamps. The total luminous power is estimated at 7,704 carcels, instead of 1,357 carcels, which are now obtained from the gas. The mains will all be of bare copper, on porcelain insulators. The engines will be placed in a separate building. Moreover, some of the cables belonging to the sector of the company will be brought into this building to ensure the lighting in case of accident. This building will contain four Roser boilers, four steam engines of 150 H.P., four Desrozier's dynamos of 780 ampères, with a difference of potential varying from 120 to 165 volts, for charging the accumulators, and a battery of accumulators supplied by the company for the electrical working of metals of a total weight of 13 tons. The total cost of establishment will be 406,000 francs, which will be laid out as follows:—76,000 francs for the mains, 74,000 francs for the plant, 71,470 francs for the engines and boilers, 90,400 francs for the dynamos and distribution boxes, 31,140 francs for the accumulators, and the remainder for erecting and unforeseen expenses. The total electrical energy per year will be 2,922,162 hecto-watt hours, which will be supplied at a charge of 153,365 francs, or, on an average, at ·0525 franc for the hecto-watt hour. At the end of 15 years the mains, which will then have a value of 75,000 francs, will belong to the City of Paris; but the authorities will have to pay 128,000 francs in order to gain possession of the works. For private consumers living in the neighbourhood, and desiring to be supplied with electrical energy, the price will be ·06 franc per hecto-watt hour, not including the cost of installing meters. M. F. Henrion had made similar proposals, offering to supply 34 arc lamps of 12 ampères, 58 arc lamps of 8 ampères, 14 arc lamps of 6 ampères, 334 16-candle incandescence lamps, and 174 10-candle incandescence lamps, for a total cost of establishment of 330,000 francs. The price of the hecto-watt hour was ·0564 franc; but at the end of 15 years the whole installation was to revert to the city. Thus the two projects were equal from a financial point of view. However this may be, we are glad to find that the electric lighting of the slaughter-houses, while supplying six times as much light as gas, will effect a saving of 15,600 francs a year.

The Accidents of the Popp Company, Paris.—Nearly all the electrical accidents that have happened in Paris are due to the Popp Company. This is the last that has happened. On November 25th last, an explosion took place at No. 5, Ruy Royale, at about 4 o'clock, plugs were forced out and sent up into the air. At the same moment some conductors were burnt at the Larne restaurant on the Boulevard de la Madeleine, 300 metres off. Several other more or less serious accidents happened at the same time at the houses of other consumers. The explanation given of this accident is as follows:—During the service, a workman placed the charging current on the discharge circuit instead of the charge circuit. Now the canalisation of this circuit is constructed for 110 volts instead of 1,500 to 2,000 volts. The result was heating and defective insulation. Contacts ensued with the gas mains, and this brought about the explosion. This accident is not the first that has happened in their canalisations. Therefore, in order to avoid, or, at any rate, to lessen their responsibility, the new directors have entrusted to M. J. Brancion the management of the electrical works, and to M. J. Leclaire that of the compressed air works. The company for the electrical working of metals continues to take charge of the accumulators placed in the company's stations. The old Telephone Company is charged with the canalisation. These arrangements do not seem to suit the City of Paris. A municipal councillor has recently presented a proposition demanding the winding up of the Popp Company.

Testing Coils.—A short circuit between two or more turns of a coil of a galvanometer or of an armature is a somewhat difficult fault to detect in the ordinary way. Lord Rayleigh has employed a very ingenious method. Two coils of an induction balance are arranged so that there is a balance. The coil to be tested is then brought near one of the coils of the induction balance. If there is a short circuit in it it will act as a secondary circuit, and this will throw the balance out. This method, says *Industries*, has been independently developed by engineers so as to be applicable to cases where the insulation does not give way until considerable pressure is brought to bear on it. In 1888 a method of testing direct-current Gramme armatures was introduced at Messrs. Crompton's works at Chelmsford. The armature circuit is opened and an alternating current is put on part of it; the armature can thus be tested as a choking coil or as a transformer without being mounted, and before the commutator is connected. We believe Messrs. Goolden and Co. devised the same method shortly afterwards, if not before. Messrs. Ferranti & Co. have for several years adopted a similar method for testing their transformer coils before building up their transformers. Temporary cores are put in and worked with high pressures. The Thomson-Houston Company, of America, are now using a similar method for testing coils.

Electric Railway Extensions.—The Bills have just been deposited at the Private Bill Offices, which indicate the proposals for the extension of the electric underground railway system in the metropolis, which Parliament will be asked to sanction in the coming session. The Clapham Junction and Paddington Railway Bill, to which we referred last week, proposes the incorporation of a company, the promoters of which include the names of Baron Sudeley, the Hon. E. S. Churchill, Mr. D. F. Carmichael, and other gentlemen. The capital of the company is fixed at £1,050,000 in shares of £10 each, with power to borrow on mortgage £350,000. It is provided that the works under the Thames are to be executed under the direction of the Conservators, and the company is not to interfere with the bed of the river or to erect any permanent works in the river. The period for the completion of the works is fixed at five years from the passing of the Act, and there are special clauses following in the lines of recent legislation for the conveyance of the working classes over the line at certain times in the morning and evening at the rate of a penny per journey. Power is taken in the Bill to pay interest at the rate of 3 per cent. out of capital during construction. The Edgware Road and Victoria Railway Bill provides for the incorporation of a company, including the names of Sir Frederick Johnstone and others, for the purpose of making a line four miles three furlongs six chains in length from Edgware Road to Vauxhall Bridge Road at Victoria, with a subsidiary line one furlong four chains in length from High Road, Kilburn, to Dyne Road, and a subway for pipes, wires, cables, and other apparatus under the Edgware Road. The mode of construction and manner of working is to be similar to that of other proposed electric railways, and the capital of the company is set at £1,200,000 in 120,000 shares of £10 each, with power to borrow on mortgage £400,000. The works are to be completed within five years from the passing of the Act, and provision is made for the conveyance of the working classes before seven in the morning or after six in the evening, except on Sundays, Christmas Day, and Good Friday, at fares not exceeding a halfpenny a mile. The City and South London Railway Company have also deposited a Bill asking for an extension of time for the construction of the subway authorised by their Act of 1890.

Hanley Electric Lighting.—A local government board enquiry was held on 22nd inst. regarding the electric lighting question at Hanley.

Cardiff Electric Lighting.—As soon as the sanction of the local government board has been obtained electric lighting tenders are to be applied for.

Nelson Electric Lighting.—The electric lighting scheme was inaugurated on Friday evening last, when many of the shops in the centre of the town were illuminated for the first time.

Accrington Electric Lighting.—Advancing the price of gas has again brought the electric lighting question to the fore.

Gas v. Electric Light.—Judging from the annual parliamentary returns just issued as to the position of the gas undertakings of the United Kingdom, says the *Times*, the companies have not yet been seriously affected by the adoption of the electric light.

Engineering Association of New South Wales.—We have received a copy of Vol. 7 of the *Proceedings* of the above association, which contains the various papers, &c., read during the year 1891-2.

Personal.—On board the P. and O. ss. *Britannia*, which sailed on the 23rd inst., were Mr. W. H. Preece, Mr. Henry Edmunds, and Prof. George Forbes, the two first-named, we understand, stopping at Malta.

South Staffordshire Tramways.—The opening ceremony of the electric tramways for South Staffordshire will take place to-morrow.

The Electrical Volatility of the Metals.—Some hopes were entertained a short time ago of the ultimate evolution of a commercial method, by means of which articles might be coated with thin films produced by the volatilisation of metals in the electric arc. It must be reluctantly admitted now that further experimental evidence has recently been adduced by Mr. W. L. Dudley, that the application of the electro-deposition of metallic films in this way is very limited. Gold films, it appears, may be readily procured, and the difficulties may be largely obviated by following the method of Kundt (*Ann. der Phys. Wiedemann*, xxxiv., p. 469). When the metals themselves were used as terminals for the electric arc, the film deposited was usually granular in nature, and altogether unsatisfactory. The condensed spark (Wright, *Am. J. Sci.* [3], xiii., p. 49, and xiv., p. 169,) (Hartley, *Proc. Roy. Soc.*, xlvi., p. 88,) (Crookes, *Chem. News*, lxiii., p. 287), between the two points of metal enclosed in an exhausted glass tube serve well in some cases. No relationship has yet been discovered between the degree of electrical volatility and any known constant, but a relationship might be found if the volatilisation were carried on under such conditions of temperature as would ensure molecular conditions. The metals given in the order of their electrical volatility are as follows: palladium, gold, silver, lead, tin, platinum, copper, cadmium, nickel, iridium, iron; in this list the electrical volatility of the first metal is placed at 108, that of the last at 5·5. Mr. Dudley makes a useful comparison of the order of the electrical volatility of the metals as found by Crookes, with the curve of atomic volumes found by Lothar Meyer.

Progress in the Production of Nickel.—Nickel is found in New Caledonia in a single mineral, *garnierite* or noumeite, which is a bright green hydrated silicate of magnesium and nickel. In this island the French are rapidly developing what promises to be an industry of world-wide importance. The most improved plan of extracting the metal from the ore consists in reducing the latter in a regenerative furnace resembling in structure the type of furnace used in Belgium for reducing zinc oxide. The reduced metal is afterwards sifted to separate the cubes or discs from irregular and broken masses: they are afterwards collected by means of magnets. Among the more important of the recent applications of nickel is that of the alloy (20 parts of nickel with 80 parts of copper), which is now used for the casing of bullets for some of the small box rifles which European countries are adopting in their armament. The production of nickel, which was about 400 tons in 1878, the year of the discovery of the New Caledonian ores, has now exceeded 5,000 tons per annum. In New Caledonia, arrangements are being made for an increased output: operations are being extended also in the district of Sudbury, so that from these two sources alone, a supply of about 10,000 tons of pure nickel per annum may shortly be expected. There is a long paper on the progress of the metallurgy of nickel in the *Annales des Mines*, 1892, i. p. 141, by Mons. D. Levat.

Another Cable Tramway Accident.—On Tuesday night during the dense fog eight miles of cable tramways were stopped in an instant in a very remarkable way. A car at Handsworth terminus, four miles from the city, ran into another in consequence of the grippers becoming entangled with the cable, the result being that at the engine house, two miles off, the whole of the regulating machinery was thrown out of gear. The service is still suspended.

Bangkok Electric Tramways.—Mr. W. J. Davison, of the Short Electric Company, Cleveland, Ohio, is at present in Bangkok supervising the erection of the plant for the Bangkok Tramway Company. The station is being pushed forward and it is expected that the cars will be running some time in January.

Llandudno Electric Tramway.—The question of the construction of an electric tramway along the parade has been deferred for the present.

Dalkey Electric Tramway.—The Dalkey Town Commissioners have given their consent to the use of electricity upon the lines of the Dublin Southern District Tramway Company.

Falmouth Electric Lighting.—Several letters have been received by the local authorities regarding the electric lighting of the town, and they have been referred to a committee.

Preparation of Metallic Chromium by Electrolysis.—Up to the present metallic chromium has never been prepared by electrolysis, indeed, the metal itself is scarcely known except as a laboratory curiosity. By a method of electrolysis devised by Mons. Em. Placet, it can now be rapidly and easily prepared in quantity. The outlines of this method are as follows: An aqueous solution of chrome alum is prepared and mixed with some alkaline sulphate and a small quantity of sulphuric acid. This mixed solution is then electrolysed; at the negative pole, on the face of the electrode, the metallic chromium is precipitated in the form of a brilliant film at first, but, obviously, any quantity may be thus prepared. At the meeting of the Paris Academy of Science, held on November 28th, 1892, Mons. Placet exhibited a fine specimen of electrolytic chromium, weighing upwards of one kilogramme; some chromium alloys and several brass ornaments plated with chromium by electrolysis attracted a good deal of attention.

OFFICIAL RETURNS OF ELECTRICAL COMPANIES.

Julius Sax and Company, Limited.—In an agreement, dated November 14th, made between this company and A. L. Sax and Charles W. Sax, it is stated that by a former agreement between the vendors and the company, it was agreed that the vendors should sell to the company the business carried on by them at Smithfield Market and elsewhere, in consideration for £19,930. The present agreement, however, provides for the allotment of 2,000 shares of £10 each to the vendors, in full satisfaction of their claim.

Holloway Electricity Company, Limited.—The statutory return of this company, made up to November 8th, has been filed at Somerset House, and shows that out of a nominal capital of £2,000, in £10 shares, only seven shares have been taken up, and that no calls have been made. The signatories to the memorandum of association are the only shareholders.

Blackpool Electric Tramway Company, Limited.—A resolution was passed by the shareholders of this company on September 24th last, and confirmed on October 5th last, to the effect that the company be wound up voluntarily, and that Mr. J. Oddie, of Halifax, Yorks., be appointed liquidator for such purposes.

Crossley Telephone Company, Limited.—The annual return of this company, made up to October 6th last, shows that out of a nominal capital of £100,000, 607 "A," 120 "B," and 350 "C" shares have been taken up. There has been £5 paid on each of these shares, and the total amount of calls paid reaches £5,385.

General Electric Company, Limited.—The annual return of this company, made up to November 30th last, has been filed at Somerset House, and shows that out of a nominal capital of £60,000, divided into 7,000 first preference, 1,000 second preference, and 4,000 ordinary shares, all of £5 each, 4,000 ordinary, 1,000 second preference, and 6,325 first preference shares have been taken up, the two former having been issued as fully paid. The full amounts have been called upon the 6,325 first preference shares, and all calls, reaching the sum of £31,625, paid.

Blakey, Emmott and Company, Limited.—The annual return of this company, made up to November 9th, shows that, out of a capital of £35,500 in £100 shares, that 302 have been taken up. There has been £50 called up on each of 117 shares, and the total amount of calls received reaches £5,850. The full extent of the amount considered to be paid is £18,500.

South Staffordshire Electric Lighting Company, Limited.—At an extraordinary meeting of this company, held at 33, Waterloo Street, Birmingham, on the 3rd ult., a resolution was passed to the following effect: "That the company be wound up voluntarily, and that Mr. Philip Halliby Carter, of No. 33, Waterloo Street, Birmingham, be appointed liquidator of the company.

Lithanode and General Electric Company, Limited.—The statutory return of this company, made up to the 17th ult., shows that the company is a reconstruction of the Mining and General Electric Lamp Company, Limited, and have bought the patents of the old concern, the consideration, therefore, being the allotment of 91,500 shares, each considered as having 16s. paid, to the shareholders of the previous company, according to their interests. At the present time 17,725 shares have been taken up, and a call of 2s. per share has been made. The payment that resulted from this amounts to £998 3s., and a sum of £974 7s. was left in arrears.

Monte Video Telephone Company, Limited.—The annual return of this company, made up to November 24th last, shows that out of a nominal capital of £220,000 in £5 shares, 28,000 preference and 15,000 ordinary have been taken up. There has been £5 called up on each of 25,000 preference shares, and also £5 on 12,000 ordinary shares. The total amount of calls received reaches £185,000, and the sum agreed to be considered as paid is £30,000.

Electric Date and Time Stamp Company, Limited.—A resolution was passed at an extraordinary meeting held at the office of Mr. T. S. Hamilton, at 78, Coleman-street, E.C., to the effect that the Electric Date and Time Stamp Company be wound up voluntarily, and that Mr. J. M. Henderson, of 2, Moorgate-street, Buildings, be appointed liquidator.

CONTRACTS OPEN AND CLOSED.

OPEN.

Burnley.—January 18th. For the supply and fixing of fittings for the electric lighting of the interior of the Town Hall, for the Burnley Town Council. Further particulars from Mr. F. S. Button, C.E., borough surveyor, Town Hall, Burnley.

Strasburg.—January 11th. For the supply of copper and brass wire, copper and zinc sheets, &c., for the Elsass-Lothringen Imperial Railways. For particulars apply to the Director of Stores, Strasburg.

Tournai (Belgium).—January 12th. For certain works in connection with the installation of the electric light at Ath Station, for the Belgian State Railways. For particulars apply to the Director, Belgian State Railways, Brussels.

CLOSED.

Bournemouth.—The Lighting Committee have resolved, subject to reference to the Council, to accept the tender of Messrs. Goddard, Massey and Warner, of Nottingham, for an electric lighting scheme. They are also recommending that Messrs. Goddard & Co. be asked to submit an additional tender for providing 3,000 1-candle-power lamps for illuminating purposes, and for laying on the light to the fountains to be constructed in the gardens.

Canterbury.—It is announced says the *Morning Post* that the Brush Electric Engineering Company have accepted the terms upon which the Canterbury Town Council are disposed to make over the provisional order for the introduction of the electric light into Canterbury.

BUSINESS NOTICES, &c.

Brush Electrical Engineering Company, Limited.—The Brush Electrical Engineering Company report that during the past year most of the departments of their extensive works have been kept fully employed. Contracts for central station works, for which the factories and organisation of the company generally are specially equipped, have naturally preponderated. Very considerable progress has been made with the installation at Bankside, for the City of London Electric Lighting Company, and the Brush Company are at present engaged in erecting additional sets of large generating plant, which will enable the City company to get abreast of the urgent demands upon them for light. The work in connection with the station for the Huddersfield Corporation has been delayed in consequence of a strike, which hindered the progress of the station buildings, but this difficulty has now been overcome and the works are being rapidly pushed forward. Among the other important central station contracts secured during the past year are those for the Corporation stations at Worcester and Hanley, and additional plant has been supplied for extensions at the Newcastle, Sheffield, Bournemouth, Chatham and Rochester, Hastings, Exeter, and Shanghai central stations, while orders have been received for plant for new installations at Prescot, Windermere, Killarney, Port Louis, and a number of small towns on the Continent and in the Colonies generally. Brush arc plant has been supplied to the Corporations of Dublin and Glasgow for street lighting, and the Hanley contract included similar plant for the same purpose. The Brush Company's contracts for exhibition lighting during the past year include the lighting of the Exhibition at Douglas, and the supply of the whole of the electrical plant which was used for the lighting of the International Horticultural Exhibition at Earl's Court. Amongst the large number of isolated installations secured by the company during the year, the most notable are those for Arundel Castle, the seat of his Grace the Duke of Norfolk; Southill Park, the country residence of Sir Arthur Hayter; Wetley Abbey (P. Hardman, Esq.); Letham Grange (Major Neale); the Bilston Market Hall; the Douglas Grand Hotel; the Nottingham University College; the Nottingham Castle Museum; the Lyceum Theatre, Sydney; arc lighting plant for the Caledonian Railway Company's Princes Street station, Edinburgh; the London Brighton and South Coast Railway Company's station at Victoria, and for a large extension at the works of the Consett Iron Company at Durham, &c. A large number of direct coupled engines and dynamo machines for installation on shipboard have been supplied to various governments and to shipbuilders, while the installation work on shipboard completed by the company during the year includes the lighting of H.M.S. *Sappho* and *Scylla*, built by Messrs. Samuda Bros.; two cruisers for the Argentine Government, built by Messrs. Laird Bros.; a large steamer for the Austrian Lloyd Company, constructed by Messrs J. L. Thompson and Sons, &c. Although the general depression of trade has made itself felt in the rolling stock departments of the company's manufacturing business, important orders have nevertheless been received and executed, among which may be mentioned locomotives and rolling stock for the new Beira Railway, and for the Bangkok Railway, Siam. The company have also supplied cars for electric and other traction. Considerable improvements have been made in the construction of plant adapted for railway train lighting, and orders have been received for a number of new machines for train lighting on the L. B. & S. C. Railway system, the Adelaide Government railways and elsewhere. The company have also carried out some important contracts for electrical power transmission plant both in this country and abroad during the year. The company took a prominent part in the Electrical Exhibition which was held at the Crystal Palace in the early part of the year, and their magnificent show of moving and stationary machinery and other specimens of their manufacture attracted a great deal of attention. By legal proceedings in the New South Wales Courts the Brush Company have established the validity of the Edison-Master incandescent lamp patent, of which they are the owners in the Australasian Colonies, India, the Cape of Good Hope, and Natal, the defendants in the action referred to being condemned to pay costs and damages in full. The company require that all orders for lamps for use in those countries where they hold the patent shall be sent to them, or to their Sydney branch, 56, Margaret Street, Wynyard Square, Sydney, for execution. It would not be right to close this short review of the Brush Company's operations during the past year without referring to the loss the company has sustained by the sudden death of the chairman, the late Duke of Marlborough. The death of the Duke has been severely felt not only by the Brush Company, but by the electrical industry generally, his interest and activity in all matters affecting the welfare of the industry being well-known. Mr. J. B. Braithwaite, who has been a director of the Company for many years, has succeeded the late Duke of Marlborough as chairman.

Calendars, Almanacks, &c. — The Brush Electrical Engineering Company have had prepared for 1893 a very convenient and handy little pocket memorandum book with gilt edges, and a pencil fastened at the back edge. Inside is a calendar for 1893.

The Electrical Power Storage Company, Limited, of Great Winchester Street, have, as usual, prepared a first-class combined blotting pad and calendar. A price list of E.P.S. cells is attached in kind of book form to the left hand side of the pad. This is a calendar perhaps as useful as any of its kind.

We have received from the Indo-European Telegraph Company an illustrated card almanack for 1893.

Messrs. Fletcher, Russell & Co., Limited, of Warrington, have sent us one of their 1893 calendars with a separate sheet for each day. It is a very handy and useful one, and is in Messrs. Fletcher's usual style.

The Electric Light in the City.—There does not appear to be any falling off in the number of new installations in hand in the City. Since our last report we notice that Messrs. Vaughan and Brown, of Kirby Street, E.C., have just completed work in "Ye Old King's Head" Hotel, Old Jewry, E.C.—The Brush Electrical Engineering Company are carrying out a contract at 10, Old Jewry.—Messrs. Laing, Wharton & Down, of New Bond Street, W., are at work in the offices of the Universal Life Assurance Company, 1, King William Street.—The Brush Company have secured the contract for wiring the large offices of Parr's Banking Company and the Alliance Bank, Limited, Bartholomew Lane. The new firm of Messrs. Rashleigh Phipps & Co., 102, Oxford Street, are fitting up the premises of Messrs. Elkington & Co., Ltd., at 73, Cheapside.—Electric lighting work has also recently been completed in the premises of Mr. E. G. Wood, 74, Cheapside.—Messrs. Bergtheil & Young, of 13, Walbrook, are fitting up the premises of Mr. Connell, watch and clock maker, 83, Cheapside; Messrs. Laing, Wharton & Down, of New Bond Street, have secured the contract for wiring the large establishment in Gresham Street known as Stubbs's Mercantile Office.—Electric lighting work is being carried out in the premises of M. de Silo, 11, Hatton Garden, by Messrs. Julius Sax & Co., Ltd.

The Electric Light in South London.—Good progress continues to be made in this district. Since our last report we notice that Messrs. Winn & Co., of Union Street, Southwark, are fitting up the new premises of the "Crown and Cushion" Hotel, Westminster Bridge Road.—Mr. F. W. Rayner, of Milton Street, E.C., has recently completed work in the premises of Messrs. Robert Hoe & Co., Borough Road, Southwark.—A contract has also recently been carried out at the new "Royal Victoria" Tavern, Waterloo Bridge Road, adjoining the Royal Victoria Hall.—The proprietors of the South London Music Hall, London Road, S.E., have adopted the electric light, the Planet Electrical Engineering Company, of Victoria Street, Westminster, having secured the contract for the work.

Fire at Woodhouse & Rawson's.—A serious fire broke out shortly before 4 o'clock on Sunday morning last, at Hammersmith Road, Hammersmith, upon the premises of Messrs. Woodhouse and Rawson. Through the overheating of a drying-stove, a large building of two floors, 100 feet by 40 feet in dimensions, used as offices and stores, became ignited, and the drying-room on the ground floor was a mass of flames when the firemen arrived. Four manuals and four steamers were despatched to the scene in response to the call, which was received from a special messenger, and deliveries were promptly set to work from standpipe and steamer; but the ground floor was gutted and the remainder of the premises very severely damaged.

Annual Dinner.—The employés of the Oxford Electric Company were entertained at a dinner at the works on Christmas Eve, Mr. George Offor, the general manager and secretary presiding. The proceedings were enlivened by songs, which were brought to a close, in the facetious words of the programme, by a chorus of Engines, Dynamos, and Exciters, when the time arrived for recommencing the generation of current. The Accumulators included in the system enabled the supply during Dinner to go on without the interruption of the machinery, which does not work between midnight and about 3 o'clock p.m.

The Electric Lighting of Omnibuses.—Some London General Company omnibuses are being fitted with the electric light. The battery weighs about 8 lbs., and is placed in a wooden box under one of the seats. The box is provided with two brass spring terminals which make automatic contact with the battery when it is let down into the box. The batteries and lamps are made by The Bristol Electric Safety Lamp Works, 40, Great Smith Street, Westminster, and covered by their patents. About 70 omnibuses have been lighted up to the present, and 140 will be finished by the end of the year.

Mill Electric Lighting at Yalding.—Messrs. B. Verity and Sons are engaged on some electric lighting work at Yalding. They are putting down machinery, dynamo and accumulators, of the E.P.S. type, for the purpose of lighting an Institute and Concert Hall, the Boy's Brigade Headquarters, and at Riverside, Cheveney, and Yalding Vicarage. Shortly there is to be a public exhibition of the light.

Pilsen Electric Company.—We are informed that Messrs. Gwynne & Co. have acquired the entire business, patents, and rights of the Pilsen Electric Company, which will in future be carried on in Messrs. Gwynne's electrical department at the new works, Brooke Street, E.C., in large and well-equipped premises.

Private Lighting at Dorking.—Mr. Torr Todman, of the Bermondsey Electrical Works, has recently carried out an electric lighting installation at the works of Messrs. Taylor and Brooker, timber merchants, of Dorking. There are three 2,000-C.P. and six 1,000-C.P. arc lamps provided.

Removal.—The general offices of the Commercial Cable Company in London have been removed from 18, Bishopsgate Street Within to Bishopsgate House, Nos. 55 and 56, Bishopsgate Street Within, E.C.

Private Electric Lighting. — Messrs. Egan & Sons' jewellery establishment in Patrick Street, Cork, has been lighted by electricity.

Personal.—Mr. F. T. J. Haynes, of Taunton, the telegraph superintending engineer of the Swindon, West of England, and South Wales division of the Great Western Railway, has been elected a Fellow of the Imperial Institute, on the nomination of Mr. W. H. Preece.

Mr. A. Grundy, informs us that at the New Year he is rejoining Messrs. Baily & Grundy, of Amberley Works, Paddington, as manager of the electrical and contract department.

CITY NOTES.

The Fowler-Waring Cables Company, Limited.

THE directors' report, presented at the fourth ordinary general meeting, held at the offices of the company, Victoria Mansions, 32, Victoria Street, S.W., yesterday (Thursday, 29th inst.), reads as follows:—

"In submitting the third annual report, the directors are pleased to call attention to the fact that, as they anticipated last year, there has been again an increase in the volume of business done, as compared with the previous 12 months, with the result that this year a small profit has been earned. The directors are satisfied that the business is steadily growing, and they believe that it will show continuous development with increasing profits as time goes on, more especially because a larger turnover reduces the average charge for general expenses, an item which is always disproportionately heavy in a new business; meanwhile, good orders in different departments have continued to come in since September 30th. Some interesting details of the work during the past year will be found in the annexed report of the general manager. As the shareholders have already been informed, the actual capital of the company has unfortunately proved insufficient for its requirements, and the board therefore, in May last, authorised an issue of debentures to the amount of £10,000. Of this sum £5,500 has been taken up, chiefly by the directors themselves, after full opportunity of subscribing was given to each shareholder. This amount has sufficed for the present, but the employment of a still larger working capital will be necessary before any considerable development of the business can be suitably met. The directors believe that such an increase would be justified by the results. Col. J. T. North and Mr. R. S. Waring having ceased to be directors, Mr. Geo. F. Smart has been chosen to fill one of the vacancies thus occasioned. The retiring directors, Mr. William Fowler and Mr. George Fleming, being eligible, offer themselves for re-election. The auditors, Messrs. Cooper, Brothers & Co., offer themselves for re-election.

The report of the general manager (Mr. A. E. Mavor), reads as follows:—

"In reviewing the progress of the company for the past year, it is satisfactory to note an increase in the volume of business. The electrical industry, however, has not escaped the prevailing depression, and our turnover has not yet reached a figure which would fully employ the resources of the works and staff. A brief *resumé* of the principal work completed during the year will sufficiently indicate the extent of the company's operations, and the direction in which further developments may be confidently anticipated. In my last report I referred to our contract for mains with the London Electric Supply Corporation—this has been extended, and we are still delivering large quantities of high tension concentric conductors for their system in London. We secured the contract for, and have now completed, the extensive underground electric light system at Exeter, and have at present a similar contract at Brighton. A number of Irish towns have been cabled on our system, and we are carrying out the contract for the electric light mains of a large town in Sweden. Negotiations are well advanced for similar contracts in this country. In general electric lighting work our manufactures have met with increasing favour, and have been in several instances specified for specially difficult conditions, to the exclusion of other systems. In telegraphy, the railway companies continue to employ our various types of telegraph cables, and we have now in hand a contract with the Secretary of State for India. This has been placed with our company after prolonged tests and experiments by the officers of the Government in India, who have satisfied themselves as to the high value of our insulating material in resisting the deteriorating effects of the heat and moisture of the Indian climate. We are justified in expecting that this contract will be followed by the further application of our cables for electrical work in hot climates where permanent efficiency cannot be secured with rubber or gutta-percha. Recent enterprise in telephony has stimulated the manufacturers to special exertions in the production of cables suitable for the transmission of telephonic currents over long distances, and notable advances in this direction have been made within the last few years. Since the organisation of the company's factory at North Woolwich, this important work has been the subject of constant experiment and investigation, and we are now manufacturing long distance telephone cables of the highest efficiency. It is satisfactory that the resources of our works, and the perfection of the machinery and appliances have enabled us already to undertake and successfully to complete large contracts both in this country and abroad for the new type of cable. Notwithstanding the preliminary difficulties which always beset a new industrial undertaking, and the exceptionally keen competition which we have had to meet from the beginning of our business, the constantly growing demand in every branch of electrical engineering, and the high favour with which our manufactures have been received, foreshadow the early success of the company.

BALANCE-SHEET, September 30th, 1892.

Dr.	£	s.	d.
To Capital authorised, 40,000 shares of £5 each ...	200,000	0	0
„ Issued, 20,000 shares of £5 each, fully-paid, £100,000; 300 founders' shares issued as fully-paid to vendors, £1,500	101,500	0	0
„ Five per cent. debentures	5,500	0	0
„ Creditors	14,058	10	8
„ Liability on bills receivable discounted	1,448	5	11
	£121,058	10	8

Cr.	£	s.	d.
By Cash at bankers and in hand	1,374	12	9
„ Debtors	14,128	12	6
„ Stock	25,142	9	2
„ Office furniture in City offices and in factory ...	530	10	4
„ Shares in other companies at cost	1,065	0	0
„ Machinery and plant as per last account, September 30th, 1891, £15,094 6s. 10d.; additions during the year, £1,846 19s. 3d.	16,941	6	1
„ Works and buildings at North Woolwich, outlay as per last account September 30th, 1891, £14,570 2s. 10d.; additions during the year, £211 6s. 4d.	14,781	9	2
„ Patents and goodwill as per last account, September 30th, 1891	41,000	0	0
„ Preliminary expenses	3,303	15	6
„ Profit and loss account as per last account, September 30th, 1891, £3,273 7s. 2d.; deduct profit for year ending September 30th, 1892, as per account, £482 12s.	2,790	15	2
	£121,058	10	8

PROFIT AND LOSS ACCOUNT for the Year ending September 30th, 1892.

Dr.	£	s.	d.
To Directors' fees (not drawn)	2,000	0	0
„ Rent, rates, and taxes	1,825	3	2
„ Office expenses and advertising	1,040	13	5
„ Fees on patents	107	0	0
„ Balance—Net profit for the year ending September 30th, 1892, carried to balance-sheet	482	12	0
	£5,455	8	7

Cr.	£	s.	d.
By Gross profit on cables, after deducting salaries, maintenance of machinery, and other expenses...	5,452	3	7
„ Transfer fees	3	5	0
	£5,455	8	7

At the meeting held yesterday Mr. Wm. Fowler presided.

The SECRETARY (Mr. D. Stephen) having read the notice convening the meeting,

The CHAIRMAN said, in moving the adoption of the report and accounts, he would make a few observations with regard to the present position of the company. They all regretted that they had not a dividend to declare, but he did not think any of them were surprised at that fact, as the company was still a young one, and had therefore had difficulties that all new companies had to contend with. He pointed out an important increase in the business of the company, and the improvement in its position since the last meeting. During the past year—ended December 30th, 1892—the increase of the business had been fully 20 per cent., and instead of having a loss on the year's working of £1,500, they had turned that into a profit of £480. It might not seem a great change, but it was a very important improvement, as they had now really shown a profit on the working of the year for the first time; but there was more than that in the present position. Taking the period from September 30th, 1892, to the present day, there was an increase in the business as compared with the same period last year of more than 100 per cent., which showed clearly that the business was rapidly developing. The most important point before them was that the working capital was still insufficient, as had been shown by the fact that in the current year they had had to issue debentures to the extent of £10,000, almost the whole of which had been taken or dealt with by the directors. It was important to observe here that probably still more capital might be required as the business developed, and it was perfectly evident that if the shareholders were not disposed to co-operate with the directors by subscribing for that new capital, it must be raised at heavy expense to the shareholders. The directors, however, were not disposed to allow the company to be injured by not having sufficient working capital. They had entire confidence in the future of the company if sufficient capital were provided, but that capital was essential to real and permanent progress. One reason why they did not show a larger profit was that they had to provide a larger plant than the current business might require. They must be prepared to execute large orders speedily and well at any time, and for that purpose they must have large plant and large expenses. Therefore they would see that the business required very considerable capital to well develop it. He had never seen, since the company was founded, such a list of enquiries and probable orders as they had before them at the present moment. He thought that a very satisfactory feature without going into details, and ought to help the shareholders in forming their opinion as to the future of the company, and as to their desire to co-operate in providing fresh capital when needed.

LORD MEDWAY seconded the motion.

Mr. SEON and Col. WYNDHAM MURRAY, M.P. (shareholders), expressed surprise and disappointment that they had no dividend.

These gentlemen having been replied to by the CHAIRMAN, the resolution was put to the meeting and carried unanimously.

The re-election of directors and auditors, as stated in the report, closed the meeting.

Elmore's Foreign and Colonial Patent Copper-Depositing Company, Limited.

THE third annual ordinary general meeting of this company was held on Friday last, December 23rd, at Cannon Street Hotel, Mr. J. J. Atkinson presiding.

The SECRETARY (Mr. J. Shurmer) having read the notice convening the meeting,

The CHAIRMAN said: Gentlemen,—At the outset of my remarks I would like to remind you that ours is a syndicate company, formed not for carrying on industrial operations, but for the sale of our patents in foreign countries, and that the value of our assets, therefore, largely depends on the success of the subsidiary companies so formed, and I need hardly remind you that in the three years of the company's existence we have met with no little success, inasmuch as we have disposed of several of our most important patents, and have paid back in dividends the whole of our priority share capital. The accounts, which are before the meeting, are plain, and do not require much explanation, except, perhaps, a word in regard to the market value of our assets. At the end of last year the value of these was considerably higher than it is at the present moment; but it is in accordance with the usual practice to show such investments at cost price in the balance-sheet, whether they be at a discount or at a premium. I am convinced that in the course of the coming year the market value of these assets will very materially improve. It is the intention of the board to have the accounts for 1892 prepared immediately upon the expiration of the present year, and to meet the shareholders with the same not later than February next. The year 1891, which is now under consideration, did not see the formation of any new Elmore companies, and the year, as mentioned in the report, has been one of establishment and development of existing Elmore factories. I feel exceedingly loth to venture upon prophesy or mere promises in regard to the position and prospects of this or of any of the Elmore companies; but, gentlemen, I cannot refrain from assuring you most emphatically and deliberately, after further close and personal experience of the working of the companies since we last met you, that, notwithstanding the seeming failures and the many disappointments that have beset our path, yet the coming year will be one of substantial prosperity to the manufacturing companies from a shareholder's point of view. We have to admit that we have no doubt been too sanguine in respect to the length of time required to overcome the difficulties of starting and developing a new business, aggravated as they have been in one case by the smallness of the working capital available; but these difficulties are now removed, and the Elmore process to-day is perfectly successful on a commercial scale, and I am certain that, as a consequence, our own assets will considerably improve, and, as a further consequence, we shall also be able to dispose of others of our unsold patents. We have refrained from alluding in our report to the operations of the company during the present year, as it is our intention, as I have already said, to meet you again very shortly; but I may here say that we have during the present year had to very largely assist the French Elmore Company financially, our advances to them being secured by mortgage at interest, and the wisdom of this policy cannot be better seen than by looking at the undoubted success which that company has now achieved at its works, and which could not have been achieved but for the assistance we have rendered them, and thereby we have secured an established value to our very large stake in the French Elmore Company, in the shape of shares and debentures, which would certainly have been practically wiped out had any financial disaster occurred to the French Company. Not only so, but in helping to make the French Company a commercial success, we have also been doing good service to the other Elmore companies. It would have been a great pleasure to the directors to have found themselves again in the position of declaring a dividend of 100 per cent. to the priority shareholders; but, as stated in the report, we hope to be able to do this in the course of 1893, and if you ask me on what grounds I think it is possible, I reply that I honestly believe, and know, that the Elmore process is perfectly successful, and that, consequently, with proper management, the companies themselves will be successful, thus enabling us to realise our investments for considerable sums in cash, and at the same time enabling us to dispose of our patents. Only this week we had a firm offer of a substantial sum in cash down for our ordinary shares in the French Company. This we have declined, as we do not consider it good enough, in view of the assured financial and industrial position which the French Company now really occupies, and it was to give the French Company time to attain to this position that we have reluctantly deferred our meeting until so late in the year; but, as before stated, we intend to publish the 1892 accounts within the next few weeks, and now that the funds required by the French Elmore Company have been arranged for, I have every reason to believe that between now and our meeting in February next the value of our investments, as shown in the balance-sheet, will have considerably improved above the price at which they stand to-day. We shall be happy to answer any inquiries from the shareholders. I now propose: "That the accounts and report, as submitted to this meeting, be received and adopted."

Mr. JOHN MACFARLANE seconded the motion.

Mr. INVERARITY proposed, as an amendment: "That the report and accounts be not passed." He did this, he said, not in any captious spirit, but because he thought the position of the priority shareholders should be thoroughly understood. He maintained that their rights and privileges had been seriously invaded by the loans made to the French and German companies in the year under review.

The SECRETARY said there had been no loan whatever to the German company.

Mr. INVERARITY contended that the loan to the French company was illegal, and he quoted the articles of association in support of his view. Not only that, but he found that 10 per cent. had been guaranteed by the directors upon £200,000 of the French company's shares. ("No!") That, also, he claimed to be illegal, and he warned the directors that he should hold them individually and collectively responsible for any loss the priority shares might suffer from their proceedings. He hoped the shareholders would not take the responsibility of passing the accounts. He also contended that the method of paying the directors was illegal, and quoted one of the articles to show that the remuneration ought to be voted by the shareholders at the general meetings.

Mr. NIAS seconded the amendment.

The SOLICITOR (Mr. Hays) said he could not deal with the question whether the policy was judicious or not, but legally the directors' action was not open to objection. He justified their action from the memorandum of association, which, he said, overrode even the articles of association. As to the directors' remuneration, Article 72 provided that not more than £1,500 per annum should be appropriated by the directors until the board exceeded seven in number, when the remuneration should be £2,000.

Mr. INVERARITY disputed the legal ruling of the solicitor, and said the question was so important that he should take the opinion of counsel upon it.

Mr. SIMPSON said in the accounts £9,000 appeared to be credited to the company as security by loan to the French company "as *per contra*;" but the other side of the balance-sheet showed no "*contra*" to that. If those securities had been parted with, why give themselves credit for them among the assets? Then he wished to draw attention to the very serious leakage which had taken place in the value of the securities in 1891 as compared with 1890—a leakage of £30,000 in the value of the French and German securities held. He complained of the date at which the accounts were presented. They were dated April 5th, and why on earth were they not presented until December? The chairman had told them that the practice of companies was to value the securities at cost price irrespective of the market price—which might or might not be right; but how could a balance-sheet issued eight months after the date to which they were made up be any guidance to them in estimating the value of the assets? As a practical guide to the company's position it was a farcical document.

A SHAREHOLDER remarked that at the last meeting there were eight directors, whereas he now saw only four of those gentlemen. What was the explanation to that?

Mr. FREDERICK L. RAWSON, M.I.E.E. (director), said the chairman had asked him to reply to the points raised, as he was more familiar with the details. He would deal first with the main policy of the company, because that was the pith of the thing, and put before the shareholders the position the board was in at the end of last year, when their policy had to be determined. At that time, as they were aware, they were all in great expectation. They had had a meeting of the English shareholders, and were given to understand that the works were going to turn out a much larger amount than hitherto, and that big profits might be looked for—they were all going to be millionaires in a very short time. With regard to the actual results they had been mistaken, and where they were wrong was in regard to the general organisation of Elmore matters, which had not been at all satisfactory. They were in the position that they held a large amount of securities—nearly all of their assets were shares in the different companies. The remainder of the assets were patents for the different companies. Patents were things they could sell if everything went right; if things went wrong, it was impossible to sell them. They were of no use unless they had plenty of money to work them. They found that the French Company was hard up, and the question was whether they were to be allowed to fail. Speaking as an expert, if the French Company had failed he believed the whole of the Elmore companies would have been smashed up. The position was this: the English Company had nothing like borne out expectations as regarded the out-turn, and all of them were hard up excepting this company, which had a certain amount of money. They had long and anxious discussions with regard to the position of the Elmore companies, and the question was how they could pull them through while they were getting over their initial difficulties. He had consultations with some of the largest shareholders, and the conclusion they all came to was that their best course was to lend the French Company a certain amount of money, taking as security a second charge on the property—after the debentures. He advised the directors that if that money were found, the French Elmore Company would be able to find enough money to pull them through. The directors cross-examined him, and he gave his facts and figures, and laid out a scheme, which they adopted, the French Company being thus saved. They lent the French Company certain of their securities, and on those they were able to borrow further money for their purposes. If the French Company had not made the serious mistake of letting people know they were hard up they would have had no further trouble after they were helped by this company, and this company would by this time have got their money back. A shareholder had asked why the directors of this, the Foreign Company, had not called the shareholders together and explained the position; but if they had done so they would have made the same mistake that had been made by the French Company—letting the world know that the latter company was hard up, and thus making it very difficult to raise capital. They knew, on the authority

of leading experts, that the Elmore process was a magnificent thing; but the great mistake they all made was in imagining that they could make a lot of money out of it immediately, instead of making allowance for the time everything of that sort took to work out. He hoped the shareholders would agree with him that, in helping the French Company, under the circumstances he had stated, they had done the best they could in the interest of this company. They had obtained £35,000 for the sale of the American patent, and that was how it was dealt with. The result had been that the French Company had been able to pull through. They had managed to pay their French creditors, had borrowed some money from outside people besides this company, and made a contract with some responsible people for placing debenture stock, receiving £19,000 on account. Therefore all the difficulties and dangers in regard to that company were over. They had been steadily turning out 10 or 11 tons a week for some time, and getting continuous orders from large firms. This had greatly improved the general position of this company—an evidence of which was that the directors had had an offer to buy the Russian patents, while they had also had offers in regard to the Belgium patents, which, however, they had not considered good enough to accept. A question had been asked as to the company's guarantee on £200,000 of the preference shares of the French Company, but the amount stated was wrong; the guarantee related to a very small amount, and the later shares had no guarantee at all. Of course, when they lent money to the French Company they did not do it for nothing; they did it for interest and a bonus besides, which more than covered any amount for which they were liable under the guarantee. Speaking of a suggestion that there had been a rigging of the shares on the market, Mr. Rawson said he had no knowledge of anything of the kind. With regard to the securities per contra, it would be noticed that the amount mentioned (£9,000) was not added up in the total; it was only put into the accounts to give the information that the securities were lent—which had been done under the circumstances he had described. The reason of the delay in presenting the accounts would be gathered from the remarks he had made. If they had had that meeting while the French Company was in the position it was some months ago, that company would not have been able to borrow the money they had since done. As to the valuation of the securities, he thought it would have been better to have explained in the balance-sheet that nominal prices were given. As to the changes on the board, one director had to leave on account of an official position. With reference to Mr. William Elmore, the directors of the English Company insisted on his resigning his position on all the companies in the south, and giving the whole of his time to the works at Leeds.

A SHAREHOLDER said he did not think an outturn of 10 tons a week proved that the French company was now on a sound basis.

Mr. RAWSON said 10 tons a week paid expenses, and a steady outturn to that extent was proof of soundness, because, with the provision made, 20 tons or even 100 tons a week could be just as easily turned out. With regard to the reduced amount of securities to which Mr. Simpson had referred, the sundry creditors, which had stood in the previous year at £47,000, were in these accounts reduced to £5,000.

Mr. PIXLEY explained several points in regard to the accounts, and said the books were perfectly clear.

Mr. RAWSON suggested that the meeting should name five gentlemen to act as a consultative committee, to assist the board in dealing with any such circumstances as had arisen in the case of the French company, though he said he did not anticipate any such occasion arising.

After some further discussion the board undertook, at the suggestion of Mr. Inverarity, not to lend any money or securities to other companies before the next annual meeting. Several shareholders still objected to passing the accounts. The amendment was ruled out of order as being a direct negative.

The original motion was then agreed to, by 28 votes against 22.

The CHAIRMAN proposed the re-election of Mr. Rawson to his seat on the board.

Mr. RAWSON commented on the anxiety he had laboured under and the heavy responsibility thrown upon him, and said he had determined that unless his re-election were unanimous he would not accept it.

The CHAIRMAN: We cannot do without him, gentlemen.

Mr. INVERARITY: I will second the motion.

The motion was then put and carried unanimously.

The auditors (Messrs. Jackson, Pixley & Co.) were reappointed, and the proceedings then closed with a vote of thanks to the chairman.

Elmore's Wire Manufacturing Company, Limited.

THE directors' report to be presented at the meeting *to be held at Leeds* to-day reads as follows:—

"The directors beg to submit their report and the company's accounts for the year ending 31st October last. Since the last general meeting several attempts have been made to commence manufacturing on a large scale, but until recently these have been frustrated by difficulties of a mechanical nature which have only been overcome by patient perseverance and determination on the part of our managers. In establishing and developing an entirely new business, in which every separate piece of machinery has to be specially designed and made for a purpose never before undertaken, it will be readily understood that many obstacles are met with which could not possibly have been foreseen. These obstacles always involve considerable cost for necessary alterations of plant, and cause vexatious delays, and in our own case have consumed practically the whole year through which the company has just passed. It is, however, highly satisfactory that the directors are able to state most positively that every difficulty which has arisen has been of a purely mechanical nature, and in no single instance has anything occurred to lessen their faith in the process itself as an electro-metallurgical operation. By the manufacture of a considerable number of copper cylinders of large diameter, for use in the company's works as mandrels, invaluable experience has been gained, as the cylinders so made are identical with the intended normal manufactures of the company. Their uniformity of quality, homogeneity, true circular section, and their tensile strength and ductility being in the highest degree satisfactory, ensuring the certainty of our being able to produce copper sheet of an exceptionally large size, with a glass-like surface on both sides, on a commercial scale, in addition to tape, ribbon, &c., of superior quality, and of higher electrical conductivity than is possible to be produced by any other existing process, and which will command for our productions the first place in the market. The company's manufacturing operations are of a perfectly simple and continuous character, producing a uniform article, for which an enormous demand exists, and the directors now have pleasure in assuring the shareholders that ample working capital has been provided for, and that the works are completed and have been furnished with a large supply of raw copper, and that practical operations have commenced. Mr. J. J. Atkinson and Mr. J. T. Cooper retire from the board by rotation, and being eligible offer themselves for re-election. The auditors, Messrs. Deloitte, Dever, Griffiths and Co., also offer themselves for re-election.

BALANCE SHEET, October 31st, 1892.

DR.	£	s.	d.
To nominal capital—150,000 ordinary shares of £2 each, £300,000; 10 founders' shares of £2 each £20, £300,020; share capital issued—68,885 ordinary shares of £2 each, £137,770; less 1,360 shares forfeited, £2,720 = 67,525 = 135,050; less calls in arrear, £5,953 10s. 4d. = 129,096 9s. 8d.; add amount received on forfeited shares, £390 = £129,486 9s. 8d.; 10 founders' shares of £2 each, £20 ...	129,506	9	8
„ Premium on shares issued—£1 per share on 65,525 shares, £65,525; less in arrear, £1,870 = 63,655; add premium received in respect of shares forfeited, £62 10s. = £63,717 10s., of which one-half credited to vendors in part consideration of purchase price	31,858	15	0
„ Reserve fund—one-half of premiums received to date	31,858	15	0
„ Mortgage and interest accrued to October 31st, 1892	10,373	5	9
„ Bank overdraft, Leeds	164	11	2
„ Bills payable	448	8	8
„ Sundry creditors (including directors' fees unpaid, £1,168 18s. 6d.)	6,909	4	7
	£211,119	9	10

CR.	£	s.	d.
By Cost of licenses, including one-half of premium on shares issued, as *per contra*	111,940	0	0
„ Cost of land at Leeds	13,000	0	0
„ Buildings, as at October 31st, 1891, £25,891 5s. 6d.; materials used, wages paid, and architect's fee during the year to date, £4,988 18s. 1d.	30,880	3	7
„ Plant and machinery, as at October 31st, 1891, £15,391 5s. 9d.; additional purchases, wages paid and stores used during the year to date in extending and perfecting the plant, machinery, &c., less sundry sales, £27,184 13s. 8d.	42,575	19	5
„ Stock of raw copper at market price on October 31st, 1892, £2,398 1s.; stock of stores, at cost, £1,412 0s. 5d.	3,810	1	5
„ Furniture, fixtures and fittings	497	19	2
„ Packages not returned, taken at cost	63	8	8
„ Cash at London bankers and in hand	89	19	6
„ Sundry debtors	483	18	9
„ Administration expenses, &c.—Balance from last year, per accounts at October 31st, 1891, £2,574 4s. 11d.; expenditure during year to date, rent, rates and insurance, £227 1s.; stationery, printing and advertising, £131 15s. 6d.; travelling expenses and carriage, £89 14s. 6d.; law charges and auditors' fees, £345 10s.; salaries, £1,956 8s. 6d.; directors' fees, £1,198 18s.; office expenses and sundries, £300 1s. 4d.; laboratory expenses, £431 12s. = £4,681 0s. 10d. Deduct interest received and charged less interest paid, £188 6s. 8d.; also transfer fees, £46 11s. 6d. = £4,446 2s. 8d.; depreciated value of raw copper stock, &c., £757 11s. 9d. ...	7,777	19	4
	£211,119	9	10

We have audited the books and accounts of the company in London, with which have been incorporated the returns of expenditure at the works in Leeds, certified by the managing director or book-keeper, and the above balance-sheet is correctly prepared therefrom. All additions to value of buildings, plant and machinery, also the stocks, are the subject of a certificate by the managing director or book-keeper.

DELOITTE, DEVER, GRIFFITHS & Co.,
Auditors, Chartered Accountants.

4, Lothbury, E.C., *December 21st*, 1892.

The Yorkshire House-to-House Electricity Company, Limited.

A MEETING of the shareholders in the above company was held at the Great Northern Hotel, Leeds, on Wednesday afternoon. Mr. GROSVENOR TALBOT presided, and moved the adoption of the report. In doing so he said the directors had done a great amount of work. They had obtained the provisional order, giving them power to light Leeds by electricity, and he was told they were not likely to be interfered with so long as they supplied proper light. They had purchased an estate in Aire Street, which possessed many advantages. With regard to the question of material, an important one to the company, machinery was very cheap, and copper, which was largely used by the company, was cheap also. They could get water from the Aire, and coal could be brought to their works on the same river. They had adopted Mr. Hammond's scheme successfully worked in other towns. 8,000 applications for electric light at eight candle-power each had been received, and all the cables had been laid with the exception of those to Headingley, which could be laid down in a few days.

Mr. ROBERT WM. EDDISON seconded the motion, which was supported by Mr. HAMMOND and adopted.

Mr. Grosvenor Talbot and Mr. R. W. Eddison were re-elected directors, and Mr. Hammond, electrical engineer. Mr. John Gordon, jun., was re-elected auditor. The chairman was thanked and the meeting ended.

Elmore's Patent Copper Depositing Company, Ltd.

THE directors' third annual report reads as follows:—

"You were notified by circular on the 3rd ult. of the reorganisation of the board, and of the removal of the offices to Leeds. The directors now beg to submit herewith the balance-sheet and accounts for the year ending June 30th last. During the year in question the output has been small, nevertheless the trading account shows a satisfactory profit. The smallness of the output is accounted for by the fact that many times during the past 18 months our works' managers have prematurely considered that a state of finality had been arrived at in the mechanism necessary for carrying out the process; and the directors wish to emphasise the fact that all the difficulties which have arisen in the application of the process have been merely mechanical, that is to say, no difficulty whatever inherent in the process itself as an electro-metallurgical invention has arisen, but, as often happens in the development of an entirely new industrial enterprise, fresh difficulties have arisen with the fresh experiences entered upon, and consequently the company has been obliged to refuse large orders which might otherwise have been secured. However, after an extended experience in the working of the factory, the directors are more than ever convinced that the monopoly which the company has secured is a very valuable one, and that the process can be operated with perfect success. Under the personal control and supervision of the new board, the company is now making good progress, and in the course of the coming year the shareholders may look for a much more satisfactory statement of the company's position. The committee of Lloyd's Register of British and Foreign Shipping, under whose certificate the great bulk of the shipping launched in this country every year is built, after careful examination of, and thoroughly testing, our tubes, have signified to the company that pipes of our manufacture may be used in vessels classed in their Register under the same conditions as ordinary copper pipes, which are approved by the committee for the same purpose. This fact alone is indisputable evidence of the commercial value of the Elmore process, especially in view of the fact that the company can make seamless copper tubes of any required diameter, which is not possible by any other existing process. Some additional plant is therefore being laid down to enable the company to deal with the large demand which exists for seamless copper steam pipes, for which it has the offer of some very important and continuous orders. The establishment and development of the works have taken a much longer time than was anticipated, but beyond this all the expectations formed of the Elmore process have been realised, namely, that the quality of the products is superior to anything in competition with them, that the cost of production is lower, and that the process can be worked on a large commercial scale. The board have asked Mr. William Elmore, the managing director, to report to them more in detail upon the company's operations during the year now under consideration, and a copy of his report is enclosed herewith.* Mr. J. T. Cooper and Mr. William Elmore retire from the board by rotation, and being eligible, they offer themselves for re-election. The auditors, Messrs. Price, Waterhouse & Co., also retire, and offer themselves for re-election."

BALANCE-SHEET, June 30th, 1892.

Dr.	£	s.	d.
To Nominal capital—100,000 shares of £2 each ...	200,000	0	0
Of which there have been issued 82,395 shares fully paid	164,790	0	0
„ Mortgages on land and interest to June 30th, 1892	41,837	3	0
„ Sundry creditors	4,409	4	4
„ Royalties received in advance on copper sheet license	4,375	0	0
„ Reserve account, being profit on land sale and premiums on new shares, as at June 30th, 1891, £8,558 7s.; add premiums received on new shares issued during the year, £3,273 15s. ...	11,832	2	0
	£227,243	9	4

Cr.	£	s.	d.
By Land at Haigh Park, Leeds, as at June 30th, 1891	60,938	13	8
„ Buildings, sidings and wharf, as at June 30th, 1891, £11,524 15s. 6d.; additions during the year, £2,854 18s. 9d.	14,379	14	3
„ Plant, machinery, &c., as at June 30th, 1891, £22,449 16s. 11d.; additions during the year, £13,472 17s.; less depreciation, £2,244 19s. 8d.	33,677	14	3
„ Patents, as at June 30th, 1891, £80,702 17s. 6d.; add laboratory salaries and expenses during the year, £618 18s. 10d.	81,321	16	4
„ Sundry debtors, £3,885 14s. 5d.; ordinary and founders' shares in Elmore's Wire Manufacturing Company, Limited, at cost, £11,958 9s.	15,844	3	5
„ Stocks-in-trade, viz.:—Raw material, £5,639 1s. 6d.; manufactured goods, £3,549 14s. 6d.; sundry stores, £988 15s. 10d.	10,177	11	10
„ Fixtures, furniture and fittings	946	15	3
„ Cash at bankers and in hand	2,094	5	8
„ Profit and loss, balance as per account annexed, £8,566 5s. 6d.; less balance of profit, as at June 30th, 1891, £703 10s. 10d.	7,862	14	8
	£227,243	9	4

PROFIT AND LOSS ACCOUNT FOR THE YEAR ENDING JUNE 30TH, 1892.

Dr.	£	s.	d.
To Advertising	141	13	6
„ Travelling expenses and general charges	593	9	10
„ Rents, rates, insurance, &c., balance of account ...	135	11	4
„ Income tax	630	0	0
„ Stationery, printing, and postages	352	17	3
„ Maintenance of patents, legal and professional charges	382	0	4
„ Maintenance of plant and repairs	1,265	13	5
„ Depreciation of Plant	2,244	19	8
„ Directors' fees...	1,431	3	0
„ Salaries, balance of account	1,254	17	9
„ Agency expenses	114	13	1
„ Estate improvements	114	14	5
„ Interest and discount	1,756	19	6
	£10,418	13	1

Cr.	£	s.	d.
By Factory account	772	17	3
„ Sales of licenses and commissions	753	15	0
„ Transfer fees	138	7	0
„ Rent and produce of land, Leeds	187	8	4
„ Balance carried to balance-sheet	8,566	5	6
	£10,418	13	1

We have examined the above account with the books and vouchers of the company, and find the same correct, subject to provision for any depreciation which may have arisen in the value of the patents (to the account of which the laboratory salaries and expenses have been carried), and in the value of the investment in the shares of Elmore's Wire Manufacturing Company, Limited.

(Signed) PRICE, WATERHOUSE & Co.

December 6th, 1892.

* We were unable to obtain at the company's office a copy of Mr. Elmore's report.

The Woodfield Syndicate, Limited.

THE directors' report reads as follows:—

"The directors have pleasure in submitting herewith the balance-sheet and statement of accounts from the formation of the syndicate up to the 30th November last. The syndicate was formed on 16th May, 1891, and at once completed the purchase from Messrs. W. T. Goolden & Co. of their patents for electrical coal cutting. Shortly afterwards a contract was entered into with the owner of Nostell Colliery, and the necessary plant was put down in December, 1891. The plant proved thoroughly satisfactory, and the machine has cut as much as 370 yards in three shifts, at times attaining a speed of a yard a minute. The directors also entered into a contract for putting down a plant at Eldon Colliery, near Bishop Auckland, but being pressed by colliery proprietors, who had seen the machine at work at Nostell, to arrange contracts for other pits, which was beyond the scope of the syndicate's operations, a group of large coal owners in the north was approached, with the result of the formation of the Electrical Coal-Cutting Contract Corporation, Limited, with a capital of £402,000, which purchased the English patents and plant of the syndicate for the sum of £206,446 3s. 1d., as follows:—£11,446 3s. 1d. in cash, £20,000 in ordinary shares of £5 each, £100,000 in deferred shares of £5 each, and £75,000 in deferred payments in cash or ordinary shares. Out of this sum the directors have paid the following interim dividends:—(*a*) To the "A" shareholders a dividend of £1 per share in ordinary shares of the corporation, being the total amount of dividend to which they are entitled under the Memorandum of Association. (*b*) To the "B" and "C" shareholders (whose rights were amalgamated on the 2nd March, 1892) a dividend of £42 per share, viz., £2 in cash and £40 in deferred shares of the corporation. (*c*) To the "B" and "C" shareholders a bonus of £1 per share in cash. The directors propose that a further bonus shall be paid to the "B" and "C" shareholders of 15s. per share in cash, making in all dividends and bonus amounting to £43 15s. per share for the year, and a resolution to this effect will be placed before the meeting.

In order to avoid the costly and dilatory legal process of paying out the capital of the "A" shareholders, the directors have arranged, with the consent of all the shareholders, that the "B" and "C" shareholders shall individually purchase the "A" shares with the ordinary shares of the corporation now remaining in the hands of the syndicate, which have been declared as a dividend to the "B" and "C" shareholders for this express purpose. This transaction is now being carried out, and in due course a meeting will be called for the purpose of equalising the rights of the "A," "B" and "C" shares. It will be satisfactory to the shareholders to know that the Coal-Cutting Corporation has successfully started working, and the directors have every reason to believe that the shares of the corporation will prove a valuable property. Negotiations are pending for the sale of some of the foreign patents, and the directors are pressing them on with hope of a speedy and satisfactory conclusion. During the year Mr. E. A. James and Mr. S. Rivington have retired from the Board, and Mr. S. Evershed and Mr. A. Neilson have been elected to fill their places. Mr. Ll. B. Atkinson retires by rotation from the Board, and, being eligible offers himself for re-election. The auditors, Messrs. J. F. Lovering & Co., retire in accordance with the articles of association, but offer themselves for re-election.

The Edinburgh Electric Supply Corporation, Limited.

THE annual meeting of this corporation was held at 17, St. Andrew Square, Edinburgh, on the 23rd inst. Mr. Walter Berry presided, and there was a good attendance.

The MANAGERS (Messrs. George Deas & Co., C.A.), submitted the third annual report, the more important portions of which were to the following effect:—In the second annual report submitted to the shareholders on December 23rd, 1892, it was shown that there were then 206 shareholders, representing a privately subscribed capital of £31,175, and there are now 212, with a privately subscribed capital of £32,775. Since last annual meeting the directors have taken no steps to increase the share list by advertising or otherwise, as they consider that the nominal capital of £100,000 is fairly well secured, seeing that, in the meanwhile, only nominal holdings have been applied for, which will assuredly be greatly increased if the required concession is obtained from the Town Council. The interest taken in the electric lighting of Edinburgh is daily gaining strength, and there is a strong feeling in favour of supporting a financially strong and locally influential corporation such as this, which the citizens of Edinburgh have themselves formed. On July 20th last the directors minuted the following:—"In consideration of the delay of the Town Council to proceed with the 'electric lighting of Edinburgh,' the amount of the paid up capital of the corporation to date—namely, £1,561 5s. lying in the banks—be invested in City bonds or consols, and instructed the managers to take the necessary steps to have this done. The Town Councillors have now recognised that the time has come when they must move in the matter of the electric lighting of Edinburgh, and, as may be seen by the reports of their meetings, they are proceeding with the matter as expeditiously as can be expected. Judging from present appearances, certain portions of the city will be lighted by electricity before this time next year; and the directors have every reason to hope that this corporation will be employed to carry out the work."

The CHAIRMAN, in moving the adoption of the report, said that when he addressed them on the occasion of their second annual meeting he said that they were unable to report any progress toward a definite realisation of the object for which this corporation was formed. He had to some extent to repeat the same story that day, but with the satisfactory addition that their fate must very soon be decided, for the Town Council, which had to determine if it would undertake the electric lighting of Edinburgh on its own account or delegate the authority to others, had recognised that the operations to enable it to comply with the conditions laid down by the Board of Trade must be commenced forthwith, and they would have seen from the newspaper reports that the question in all its bearings was being anxiously considered. He did not think it probable that the Town Council would undertake the work themselves. They had plenty on hand, and were already overworked. He thought it most probable that they would entrust it to this company: (1st), because of the local and representative position of their shareholders; (2nd), because of their unquestionable financial power; and (3rd), because their shareholders would be the most important consumers, and would have a paramount interest in seeing that the work was well and substantially done, with as little disturbance to the streets as possible. Their interest and those of the Town Council were in many respects identical. They should, of course, look for a fair return for their capital and risk, but to a certain extent their company might be considered as co-operative. He had no authority from his co-directors for giving an opinion, but personally he thought they were entitled to aim at 7 per cent. dividend on their shares. The directors had never advertised for shareholders or offered founders' shares or any other inducements, but nevertheless applications had come in, and they had now on their list 212 names, subscribing £32,775. The great majority of their shareholders had taken small preliminary holdings with the avowed intention of increasing their interests largely if the business was carried on, and he had no doubt that all the capital which they might choose to issue would be immediately absorbed when they were prepared to offer it. The directors had met frequently during the year, and had given much attention to new developments in electric lighting both at home and abroad, and they were quite prepared, with the assistance of their consulting and acting engineers, to enter upon negotiations at any moment. He trusted that their patience would be rewarded, and that at their next annual meeting they should not only merit the congratulations of their shareholders, but the acknowledgments of a long-suffering public for thorough work performed. He would only add that they had as many conditional orders for installations promised as justified them in anticipating solid financial success.

Mr. JOHN M. M'CANDLISH, in seconding the motion, said he was very glad to hear the hopes that were entertained of something coming out of this company. He thought the inhabitants of Edinburgh were getting very impatient on the subject of the introduction of electric lighting. They were behind many inferior towns in this matter. He also thought the public would not view with favour the corporation taking the electric lighting into their own hands, but would rather see them making suitable terms with a company such as this. Certainly no other company had anything like the claim that they had on the corporation.

The report was adopted, and thanks were afterwards given to the directors for their gratuitous services.

The Oxford Electric Company, Limited.

THE following report has been sent to us by the company:—The annual general meeting was held at the company's offices, 45, Broad Street, Oxford, on December 9th. Sir Henry Mance occupied the chair. Mr. George Offor, general manager and secretary, having read the notice of meeting,

Sir HENRY MANCE explained that no accounts could be presented, as they would have to be made up in accordance with the Act of Parliament to December 31st, after which they would be audited by the Board of Trade and presented to the shareholders as early as possible in the spring. He took the opportunity of congratulating the shareholders upon the satisfactory progress of the company since the opening of the works on June 18th last, the corporation, the University, and the citizens generally having supported the company in a very practical manner, and started them on what promised to be a most prosperous career. A contract for street lighting has been entered into with the corporation for three years upon profitable terms to the company, the current had also been introduced into seven of the colleges, viz., Brasenose, Hartford, University, Trinity, Balliol, St. Mary's Hall, and Magdalen. An agreement had also been entered into for lighting St. John's College throughout, which would be completed during the Christmas vacation. In addition to the above, the theatre, some of the hotels and banks and many of the leading commercial establishments had been supplied, the number of places connected with the company's mains being upwards of 70.

With the election of the auditor and a vote of thanks to the chairman, the proceedings terminated.

The Crystal Palace District Electric Supply Company, Limited.

THE following report has been sent to us by the company:—The annual general meeting of this company was held at the registered offices, 4, Great Winchester Street, on Wednesday, December 21st, at noon. Mr. Robert M. Meyer, in the absence of the chairman of the company presided.

Mr. GEORGE OFFOR, having read the notice of meeting, the Chairman announced that no accounts could be presented until about the month of March as the Act of Parliament required them to be made up to December 31st, and subsequently audited by the Board of Trade.

The only business transacted was the appointment of J. D. A. Norris, as auditor for the ensuing year.

Stock Exchange Notices.—The Stock Exchange Committee have appointed special settling days as under:—Thursday, December 29th—Brush Electrical Engineering Company, Limited. £125,000 4½ per cent. perpetual debenture stock. And (2) ordered the undermentioned securities to be quoted in the official list:—Brush Electrical Engineering Company, Limited. £125,000 4½ per cent. perpetual debenture stock.—Eastern Telegraph Company, Limited Further issue of £94,100 4 per cent. mortgage debenture stock.

General Electric Power and Traction Company.—The second annual meeting of this company was held yesterday (Thursday) at Winchester House, Old Broad Street. The accounts not being quite ready for presentation, the meeting was adjourned until Tuesday, January 31st. The proceedings were purely formal.

Commercial Cable Company.—The numbers are published of 1,200 mortgage debentures of £100 each of the Commercial Cable Company, which have been drawn for payment at par on January 15th.

TRAFFIC RECEIPTS.

The City and South London Railway Company. The receipts for the week ending December 25th, 1892, amounted to £727; corresponding month, 1891, £671; increase £56; total receipts for half-year, 1892, £21,584 corresponding period, 1891, £19,457; increase £2,127

The Western and Brazilian Telegraph Company, Limited. The receipts for the week ending December 23rd, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited, were £3,254.

SHARE LIST OF ELECTRICAL COMPANIES.

Present Issue.	Name.	Stock or Share.	Closing Quotation December 22nd.	Closing Quotation, December 29th.	Business done during week ending December 29th, 1892. Highest.	Lowest.
195,100£	African Direct Telegraph, Ltd., 4 p. c., Deb. Regd. and to Bearer	100	100—103	100 – 103	...	...
1,247,720£	Anglo-American Telegraph, Limited	Stock	49½— 50¼	50 — 51	50⅜	...
2,876,140£	Do. do. 6 p. c. Preferred	Stock	91 — 92	91½— 92½	91⅝	...
2,876,140£	Do. do. Deferred	Stock	10½— 10⅝	10⅜— 11	...	...
130,000	Brazilian Submarine Telegraph, Limited	10	10¾— 11¼xd	10⅞— 11¼	11	...
34,600£	Do. do. 5 p. c. Bonds	100	101 —104	101 —104	...	...
75,000£	Do. do. 5 p. c., 2nd Series, repayable in June, 1906 ...	100	106 —110	106 —110	...	...
77,978	Brush Electrical Engineering Ordinary, Nos. 1 to 63,416	3	3 — 3½	3 — 3½	3⅛	...
75,000	Do. do. Non cum. 6 p. c. Preference, Nos. 1 to 63,416	2	2⅛— 2⅜	2¼— 2½	...	...
40,000	Chili Telephone, Limited, Nos. 1 to 40,000	5	3 — 4	3 — 4	...	...
600,000£	City and South London Railway	Stock	35 — 38	35 — 38	...	...
40,000	City of London Elec. Lighting Co., Ltd., Ord. 40,001-80,000 ...	10	10½— 10⅝	10½— 10⅝	...	...
20,000	Do. do. 6 p. c. Cum. Pref., Nos. 1 to 20,000	10	5 — 5⅛	5 — 5⅛	...	...
$7,716,000	Commercial Cable, Capital Stock	$100	175 —180 xd	175 — 180	177	...
224,850	Consolidated Telephone Construction and Maintenance, Limited ..	14/-	3/16— 5/16	3/16— 5/16	...	...
20,000	Crompton & Co., Ltd, 7 p. c. Cum. Pref. Shares, Nos. 1 to 20,000	5	5 — 5⅛	5 — 5⅛	5 5/16	...
16,000	Cuba Telegraph, Limited	10	11½— 12¼	11½— 12½	...	...
6,000	Do. do. 10 p. c. Preference	10	17½— 18½	17½— 18½	...	...
12,931	Direct Spanish Telegraph, Limited, ... (£4 only paid)	5	2½— 3⅛	2½— 3⅛	...	...
6,000	Do. do. 10 p. c. Preference	5	9 — 10	9 — 10	...	...
60,710	Direct United States Cable, Limited, 1877	20	11⅛— 11⅜	11⅛— 11⅜	11⅜	...
400,000	Eastern Telegraph, Limited, Nos. 1 to 400,000	10	14⅜— 14⅝	14⅜— 14⅝	14⅝	14 13/16
70,000	Do. 6 p. c. Preference	10	15⅞— 16⅛	16 — 16⅛	...	...
200,000£	Do. 5 p. c. Debs. (1879 issue), repay. August, 1899	100	107 —110	107 —110	...	...
1,200,000£	Do. 4 p. c. Mortgage Debenture Stock	Stock	109 —112	109 —112	111	110
250,000	Eastern Extension, Australasia and China Telegraph, Limited ...	10	14⅜— 15	14⅜— 15	14 15/16	14⅜
70,600£	{ Do. 5 p. c. (Aus. Gov. Sub.), Deb., 1900, red. ann. drgs. reg. 1 to 1,049, 3,976 to 4,326 }	100	104 —107	104 —107	...	...
250,200£	Do. do. Bearer Nos. 1050—3,975 and 4,327—6,400 ...	100	104 —107	104 —107	...	...
320,000£	Do. 4 p. c. Debenture Stock	Stock	109 —112	109 —112	111½	110
122,400£	{ Eastern and South African Telegraph, Ltd., 5 p. c. Mort. Deb. 1900 redeem. ann. drawings, Registered Nos. 1 to 2,343 }	100	103 —106	103 —106	105	...
163,700£	Do. do. do. to bearer, Nos. 2,344 to 5,500	...	104 —107	104 —107	...	...
300,000£	Do. do. 4 p. c. Mort. Debs. Nos. 1 to 2016, red. 1909	100	103 —106	103 —106	...	...
45,000	Electric Construction, Limited, Nos. 101 to 45,100	10	2½— 3	2 — 2½	2⅝	2½
19,900	*Electricity Supply Co. of Spain, Nos. 101 to 20,000	5	... ..	... ...	...	...
100,000	Elmore's French Patent Copper Depositing Co., Ltd, Nos. 1 to 66,750	2	3/8— 5/8	3/8— 5/8	...	...
82,395	Elmore's Patent Copper Depositing, Limited., Nos. 1 to 70,000 ...	2	3/8— 5/8	3/8— 7/8	7/8	...
67,385	Elmore's Wire Mfg., Ltd., Nos. 1 to 67,385, issued at 1 p.m., all pd.	2	½— ¾	½— ¾	...	...
20,000	Fowler-Waring Cables, Nos. 301 to 20,300 ... (£4 10s. only paid)	5	2 — 3	2 — 3	...	...
180,227	Globe Telegraph and Trust, Limited	10	9⅜— 10	9⅜— 10	9⅞	9 15/16
180,042	Do. do. 6 p. c. Preference	10	14⅞— 15⅛	14⅞— 15⅛	15	...
150,000	Great Northern Tel. Company of Copenhagen	10	19⅛— 19⅜	19¼— 19⅜	...	...
210,000£	Do. do. 5 p. c. Debs. (issue of 1883) ...	100	104 —107	104 —107	...	...
12,134£	Greenwood and Batley, Ltd., Ordinary, Nos. 4667 to 14,000 ...	10	4½— 5⅛	4½— 5⅛	...	...
9,600£	Do. 7 p. c. Cumulative Preference, Nos. 2,667 to 8,000	10	8 — 9	8 — 9	...	...
50,000	India-Rubber, Gutta Percha and Telegraph Works, Limited ..	10	21⅛— 22⅛	21½— 22⅛	22⅛	21⅞
200,000£	Do. do. 4½ p. c., Deb., 1896	100	102 —104	102 —104	...	...
17,000	Indo-European Telegraph, Limited	25	44 — 46	44 — 46	...	...
11,334	International Okonite, Ltd., Ordinary Nos. 22,667 to 34,000	10	2½— 3½	2½— 3½	...	...
11,334	Do. do. Preference Nos. 5,667 to 17,000 ...	10	6 — 7	6 — 7	...	...
30,000	†Liverpool Electric Supply, £3 10s. paid	5	3 5/16— 3 11/16	3 7/16— 3 5/8	...	..
10,000	Do. do. fully paid	5	5 3/16— 5 7/16	5 3/16— 5 5/16	5¼	4⅞
38,348	London Platino-Brazilian Telegraph, Limited	10	4 — 6	4 — 6	...	...
100,000£	Do. do. do. 6 p. c. Debentures	100	108 —111	108 —111	...	...
49,900	*Metropolitan Electric Supply, Ltd., Nos. 6,101 to 50,000 (£9 paid)	10	6½— 7	6½— 7	6⅞	...
50,000£	Do. 5 p.c. debentures, 1 to 5,000 in bonds of £10, £20, £40	...	102 —105	102 —105	103¼	...
454,747	National Telephone, Limited, Nos. 1. to 438,984	5	4⅜— 5 xd	4⅜— 5	4 13/16	4⅞
15,000	Do. 6 p. c. Cum., 1st Preference	10	14 — 15 xd	14 — 15	14⅜	...
15,000	Do. 6. p. c. Cum. 2nd Preference	10	13⅜— 14¼xd	13⅜— 14¼	...	...
90,950	Do. 5 p. c. Non-cum. 3rd Pref., Nos. 1 to 90,950 ...	5	4¼— 4¼xd	4¼— 4½	...	...
726,477£	Do. 4½ p.c. Deb. Stock Prov. Certs. fully paid ...	...	112 —114	112 —114	114	...
48,800£	New Telephone, Limited, Nos. 25,901 to 74,700 ... (£2 paid)	10	4⅜— 5	4⅜— 5	...	...
6,318	Notting Hill Electric Lighting Company, Limited, fully paid ...	10	5 — 6	5 — 6	...	...
220,000	Oriental Telephone, Ltd., Nos. 80,001 to 300,000 (11s. only paid)	1	3/16— 5/16	3/16— 5/16	...	...
11,802	Reuter's Limited	8	7½— 8½	7½— 8½	...	...
18,680	St. James's & Pall Mall Electric Light Co., Ltd., Ord., 101—18,780	5	7⅜— 8⅛	7⅜— 8⅛	...	...
20,000	Do. do. 7 per cent. pref., Nos. 20,081 to 40,080	5	8⅛— 8⅜	8⅛— 8⅜	...	...
3,381	Submarine Cables Trust	Cert.	116 —120	116 —120	119	...
78,949	Swan United Electric Light, Limited ... ... (£3½ only paid)	5	3 — 3½	3 — 3½	...	...
37,350	Telegraph Construction and Maintenance, Limited	12	45 — 47	45 — 47	46⅜	45½
150,000£	Do do. do. 5 p. c. Bonds, red. 1894	100	103 —106	103 —106	...	...
58,000	United River Plate Telephone, Limited	5	2⅜— 3⅛	2⅜— 3⅛	...	...
146,370£	Do. do. 5 p. c. Debenture Stock ...	Stock	90 — 100	90 — 100	...	...
15,609	West African Telegraph, Limited, Nos. 7,501 to 23,109	10	6½— 7½	6½— 7½	...	...
260,900£	Do. do. do. 5 p. c. Debentures	100	100 —103	100 —103	102	...
130,000	West Coast of America Telegraph, Limited	10	2½— 3½	2½— 3½	...	...
150,000£	Do. do. do. 8 p. c. Debs., repayable 1902 ...	100	104 —108	104 —108	...	...
64,242	Western and Brazilian Telegraph, Limited	15	7 — 7½	7 — 7½	...	...
33,129	Do. do. do. 5 p. c. Cum. Preferred	7½	5½— 5⅝	5½— 5⅝	5⅝	5½
33,129	Do. do. do. 5 p. c. Deferred	7½	1½— 2	1½— 2	...	...
164,100£	Do. do. do. 6 p. c. Debentures "A," 1910 ...	100	106 —109	106 —109	...	...
230,100£	Do. 6 p. c. Mort. Debs., series "B" of '80, red. Feb., 1910	100	106 —109	106 —109	...	...
88,321	West India and Panama Telegraph, Limited	10	1⅛— 1⅜	1⅛— 1⅜	...	...
34,563	Do. do. do. 6 p. c. 1st Preference ...	10	10 — 10½	10 — 10½	...	...
4,669	Do. do do. 6 p. c. 2nd Preference ...	10	8 — 9	8 — 9	...	...
80,000£	Do. do. 5 per cent debentures (1917) No. 1 to 1,000	100	105 —108	105 —108	...	...
$1,336,000	Western Union of U.S. Tel., 7 p. c. 1st Mortgage (Building) Bonds	$1,000	120 —125	120 —125	...	...
171,000£	Do. do. 6 p. c. Sterling Bonds	100	100 —103	100 —103	...	...
59,900	*Westminster Electric Supply Corp., Ord., Nos. 101 to 42,953 ...	5	5½— 6	5½— 6	5⅝	5⅜

* Subject to Founders' Shares. † Quotations on Liverpool Stock Exchange. BANK RATE OF DISCOUNT.—3 per cent. (October 20th, 1892).

LATEST PROCURABLE QUOTATIONS OF SECURITIES NOT OFFICIALLY QUOTED:—Blackpool Electric Tramway Company, Limited, £10 (£6½ paid) 7½—7⅝.—Brush Company 4½ per cent. Debenture stock, issued at 1 per cent. premium, 100 103.—Electric and General Investment, shares of £5 (£1 paid), 1⅞—2⅛xd.—Founders' shares, 200—225.—Electric Construction Corporation, 6 per cent. Debentures, 95—98.—Electricity Supply Corporation, Ordinary of £5, 5 - 5½.—Elmore Foreign and Colonial Copper, Founders shares, 6½—7½.—European Sims-Edison Torpedo Company, shares £20 (fully paid), 20—20½.—Founders' shares, 10—20.—Halifax and Bermuda Cable 4½ per cent. bonds 80—90.—House to House Company (£5 paid) 1½—2½.—Do. 7 per cent. Preference of £5, 5½—5⅝.—Do. 6 per cent. Debentures of £100, 97—102.—Kensington and Knightsbridge Electric Lighting Company, Limited, Ordinary Shares £5 (fully paid), 5—5½. 1st Preference Cumulative 6 per cent., £5 (fully paid), 6—6⅛.—Liverpool Electric Supply Shares of £5 (fully paid), 5⅜—5⅞.—Manchester, Edison and Swan Company, £9 (£1 paid), ⅛—¼.—Queen Anne's Mansions Lighting and Heating, Deferred shares of £10 (fully paid), 10—½.—Do. 4½ per cent. Preference shares of £10 (fully paid), 10—½.—Do. Debentures, 101—103.—Woodhouse & Rawson Ordinary of £5 (£2 10s. paid), ½—¾.—£5 Preference (fully paid), ½—1½.

PROCEEDINGS OF SOCIETIES.

The Institution of Electrical Engineers.

EXPERIMENTAL RESEARCHES ON ALTERNATE CURRENT TRANSFORMERS. By J. A. FLEMING, M.A., D.Sc., F.R.S., Member. (Read November 24th.)

(*Continued from page* 779.)

V.—GENERAL REMARKS ON THE ABOVE EXPERIMENTS.

14. On examining all those diagrams in which are delineated the curves of total loss of power in the transformer and the curve of total copper resistance loss (C^2R), we see that in every case the upper curve runs *sensibly parallel* to the lower curve; in some cases most exactly parallel. In the curves for closed magnetic circuit transformers of good design the difference between the total C^2R loss and the total loss of all kinds is the iron core loss in the transformer. Hence we see that all the experiments lead to the conclusion that *the iron core losses are constant at all loads.* In no case have we found any substantial evidence that the iron core losses are evanescent at full secondary load. This last view has been held by Mr. Mordey and others. Seeing that our methods, when applied to the 6,000-watt Mordey transformer, give practically the same results at no load as Mr. Mordey obtains, it is an interesting matter to inquire how it comes to pass that the calorimetric method employed by him seemed to indicate that the whole loss in the transformer at full load was accounted for by the fractional losses in the copper. At present the writer can offer no explanation of this discrepancy. The above-described observations were all made and plotted out before the appearance of the paper of Prof. Ayrton and Dr. Sumpner, and shown to many people, but it is very satisfactory to find that their undoubtedly excellent method has conducted them to precisely the same conclusion. Hence we seem to have very good reason to believe that the total internal loss curve of a transformer can be drawn from observations of the C^2R losses and the total core loss at no load.

When we come to consider it, it is very difficult to see on what valid supposition we could conclude that hysteresis loss should be less at full than at no load. The only difference in the magnetic conditions are that in one case the iron is magnetised by a small current acting in one direction, and in the other by the difference between two currents flowing in opposite directions, but governed by the condition that the total ampère-turns remain the same. In a special experiment, I have taken the hysteresis diagram for a soft iron wire employing a magnetising force of 1,000 ampère-turns, in one case produced by 2·5 ampères and 400 turns, and in the other case by 20 ampères and 50 turns. The hysteresis areas for one complete cycle were found to be practically the same—the latter, if anything, the larger of the two. Prof. Ewing's direct evidence on this point will be remembered.

15. These measurements have brought out, in addition, another very interesting fact. In the foregoing tables for each transformer will be seen a column of figures headed *power-factor*. We have already defined this term as the ratio of the "true watts" to the "apparent watts," or product of the effective ampères and effective volts. This ratio is given for each measurement of the power. We see at once that for closed magnetic circuit transformers of good type such as the Mordey, Westinghouse, Ferranti, &c., the power-factor at no secondary load begins at a value of about 0·8 or thereabouts. For such types of transformers, however, a very little loading up of the secondary circuit—not more than one-tenth of full load—brings the power-factor up to unity. In fig. 46* are given three curves showing the progress of increase of the power-factor as the load on the secondary circuit is progressively increased. The upper curve represents the growth of power-factor (P.F.) for the 6,500 watt Westinghouse transformer. Beginning at 0·8, it rises up to unity at about one-tenth of full load. Hence at and after this very little load the apparent watts are the same as the true watts, and the real power taken up in the transformer is quite accurately given by the product of the primary terminal pressure and the primary current, effective, or $\sqrt{\text{mean}^2}$, values being understood. For an open magnetic circuit transformer like the "Hedgehog," the case is quite different. The P.F. begins at a value of 0·08 or 0·06, and it never rises up above 0·8 Hence at no stage of the load is the real power taken up by the transformer anywhere nearly equal to the "apparent watts." A transformer like the 4,000-watt Kapp appears to occupy an intermediate position, and although it has a medium power-factor to start with, its P.F. rises up to unity at about half load. The importance of this fact in alternate current station working is very great. It shows us, if we have a station wholly supplied with transformers of the type of Mordey, Westinghouse, Thomson-Houston, Ferranti, &c., that the apparent watts supplied to the transformers is the real watts at any hour when all the transformers are more than one-tenth loaded. If, however, the station is engineered with "Hedgehogs," or with that museum of transformers of all sorts and makes which some central station engineers are fond of gathering together—under the idea, perhaps, that they can "hedge" for economy and make up for the vices of one kind by the virtues of another—then in hardly any state of the load will it be safe to assume the identity of the true and apparent measures of outgoing power. We must, of course, here assume that concentric primary cables are not in use, otherwise an error of another kind may be introduced. If we take the case of a station provided wholly with closed magnetic circuit transformers, and consider it as having an average kind of load diagram, say, for the whole year—then if the measure of the "apparent units" sent out from the station is taken, I do not think that in general we shall be far out in our estimate of the true units sent out if we deduct from the apparent units about 12 to 15 per cent. and call the remainder the measure of the true units of energy sent in the whole time.

* Not reproduced.

16. On looking at the curves in which are delineated the values of the primary and secondary currents for each transformer, we note that in these the value of the primary current and $\frac{1}{24}$th part of the secondary current is plotted in terms of the secondary output. These curves are very nearly straight lines. In the case of the closed magnetic circuit transformers of large power factor the difference between these current values is constant.

Since the windings of these transformers are in the ratio of 24 to 1, it is obvious that the ordinates of the current curves may be taken to represent the primary and secondary ampère turns. If we look at the tables and examine the difference between the values of the primary current and $\frac{1}{24}$th part of the secondary current, we shall find this difference is sensibly equal to the primary current at no load, or to the "magnetising current," so called. This is only another way of stating the fact that the resultant ampère turns are constant at all loads and equal to the ampère turns at no load. The above is true only for the high power factor transformers. For the open magnetic circuit transformer it is not the case. In this last the difference between the primary and secondary ampère turns diminishes as the load increases. This is probably because there is a continual change of the relative phase of the primary and second currents in the open magnetic circuit transformer as the load is increased; whereas in the closed circuit, after the first beginning of load, the primary and secondary currents come nearly into opposition with each other as regards phase, and preserve that difference at all greater loads.

There are also, as mentioned, for each transformer a set of curves showing the total secondary drop in volts between no load and any load. Consider the case at full secondary load. The P.D. between the secondary terminals is then less than that between them when the transformer is unloaded; primary terminal P.D. being kept always constant. The difference between these secondary P.D.'s is the "total secondary drop." Part of this drop is due to the volts lost by resistance in the secondary circuit, part by resistance in the primary, and the outstanding portion is the "leakage drop," or lost volts due to magnetic leakage. In all of the "drop" curves a line is drawn in to indicate the "drop" due to secondary resistance, and in some a dotted line is added also to indicate the drop due to the primary resistance. The relation of these parts to the whole drop in volts may be examined as follows for a closed magnetic circuit transformer:—

Let v_1 be the instantaneous value of the potential difference of the primary terminals, and v_2 the same for the secondary terminals of the transformer. Let i_1 and i_2 be the instantaneous values of the currents, and let R and S be the primary and secondary circuit resistance, and N_1 and N_2 the primary and secondary turns. Then let b_1 be the induction density in the centre of the primary coil, and b_2 that in the secondary, and b the density of the leakage; or, if A is the constant cross section of the magnetic circuit, let A b_1 be the lines threading through the primary coil, A b_2 those through the secondary coil, and A b the leakage of lines. Then,

$$\text{A } b_1 = \text{A } b_2 + \text{A } b \qquad (1)$$

By fundamental equations,

$$\left.\begin{aligned} v_1 &= \text{R } i_1 + \text{A } N_1 \frac{d\,b_1}{d\,t} \\ \text{and} \qquad v_2 &= \text{S } i_2 + v_2 + \text{A } N_2 \frac{d\,b_2}{d\,t} \end{aligned}\right\} \qquad (2)$$

Hence, writing a for $\frac{N_1}{N_2}$, we have, by elimination of b_1 and b_2 between (1) and (2),

$$\frac{v_1}{a} + v_2 + \text{S } i_2 - \text{R}\frac{i_1}{a} = \text{A } N_2 \frac{d\,b}{d\,t} \qquad (3)$$

Let $v_1 = \text{V}_1 \sin p\,t$: then $v_2 = -\text{V}_2 \sin p\,t$, because the primary and secondary potentials are in opposite phases. Also, we can write $i_1 = \text{I}_1 \sin p\,t$, and $i_2 = -\text{I}_2 \sin p\,t$, at all stages of the secondary load very nearly, because the primary and secondary currents are in opposite phases, and the primary current is in synchronism with the primary P.D. at all stages of the load above $\frac{1}{10}$th. Also, we can write $b = -\text{B} \sin p\,t$, because the "leakage" is determined by and is in close synchronism with the secondary current. Hence we arrive, by substitution in (3), at the equation,

$$\left(\frac{\text{V}_1}{a} - \text{V}_2 - \text{S I}_2 - \frac{\text{R}}{a}\text{I}_1\right) \sin p\,t = -\text{A } N_2\, p\, \text{B} \cos p\,t \qquad (4)$$

The quantity A N_2 p B $\cos p\,t$ is the instantaneous value of the volts lost by leakage. Hence, taking the $\sqrt{\text{mean}^2}$ value of both sides,* and putting dashes over the letters to indicate that they now stand for the values of the currents and potentials as read on alternate current ammeters and voltmeters, we get,

$$\left(\frac{1}{a}\text{V}_1' - \text{V}_2'\right) - \left(\text{S I}_2' + \frac{1}{a}\text{R I}_1'\right) = \text{A } N_2\, p\, \text{B}.$$

Since $\frac{1}{a}\text{V}_1'$ is the value of the secondary P.D. at no load, and V_2' is that at, say, full load, the first term in the bracket is the "total drop." The second term in the bracket is the sum of the copper drop due to the secondary circuit and that due to the primary circuit, and the term on the right hand side of the equation is the drop due to leakage. Hence, if we have a closed magnetic circuit transformer with windings, say, in the ratio of 24 to 1, we have the following rule for

* This symbol, $\sqrt{\text{mean}^2}$, is a convenient abbreviation for the long phrase, "taking the square root of the mean of the squares of all the instantaneous values of the periodic quantity at equal short intervals of time throughout the period." It is the *effective* or *virtual* value.

obtaining the true magnetic leakage drop, or volts lost by leakage at full load:—Add together the product of secondary resistance and secondary current and $\frac{1}{n}$th part of the same product for the primary circuit. Subtract this sum from the total observed drop, and the remainder is the secondary volts lost by magnetic leakage.

Examining in this way all our transformers, we see that in some, such as the Westinghouse, half the observed drop is due to magnetic leakage; whilst in some, such as the Kapp transformer, magnetic leakage is very small. This is no doubt due to the way in which the primary and secondary coils are interplaced in the Kapp transformer.

From what has been said above, it is clear that we can, from certain figures of observation on a transformer, predetermine all these curves when that transformer is of the closed magnetic circuit type. For if we are given—

(*a*) The primary P.D. of terminals;
(*b*) The primary current at no load, commonly called the "magnetising current;"
(*c*) The primary and secondary circuit resistances;
(*d*) The P.D. of secondary terminals, and the secondary current corresponding to various secondary loads up to full load;

we can determine the efficiency curve and everything else.

For the product of (*a*) and (*b*) gives us the apparent watts at no load, and if we take 0·8 of this we get the core loss at all loads. Then from the ratio of the primary to secondary volts at no load, and the observed secondary currents and magnetising current, we can calculate the primary currents, and from the currents and resistances get the total $c^2 r$ loss at certain secondary loads. Hence we can draw a total $c^2 r$ loss curve and a total loss curve parallel to it, and from this last determine the efficiency at every stage of the load.

VI.—EXPERIMENTS WITH MR. SWINBURNE'S WATTMETERS.

17. As mentioned, Mr. Swinburne sent with his transformer a brass-cased wattmeter stated to be adapted for measuring alternating current power. In most of the tables giving the power absorbed by various transformers will be found a column headed "Total power taken up in transformer by Swinburne wattmeter," and in the "total loss" curves these numbers are plotted as a dotted line, marked "Losses by Swinburne wattmeter." In various cases we made measurements with the Swinburne wattmeter, as far as it would read, and our own dynamometer wattmeter, either simultaneously or immediately after one another. The Swinburne wattmeter was carefully calibrated on the same non-inductive resistance as the dynamometer wattmeter, and its constant determined. An examination of the values of the power taken up by various transformers at various loads shows that the power values given by the first sent Swinburne wattmeter are in nearly all cases lower, and often much lower, than those given by the dynamometer wattmeter. In the case of the Westinghouse transformer the two instruments gave practically the same value for the loss at no load; and for that transformer, and for the 15-H.P. Ferranti transformer, the differences in the two readings are not great at any load. It seemed that the Swinburne wattmeter gave readings, within reasonable limits of experimental errors, quite as likely to be right as not. The case is quite different, however, when it is applied to measure the power-absorption in a transformer of small or moderate power-factor. In the case of the Thomson-Houston transformer the Swinburne wattmeter gave power values only about two-thirds as great as those given by the dynamometer; in the case of the Kapp transformer rather less. Most remarkable of all, in the case of Mr. Swinburne's own transformer, his wattmeter gave power values on the average only about half of those obtained by the dynamometer wattmeter. Again and again we repeated these experiments, calibrating the wattmeters in various ways, and using every precaution. The mean of all our observations with the Swinburne wattmeter gave 74 watts as the power taken up in the 3,000-watt "Hedgehog" at no load, and the most frequent value obtained was 55 watts. We have seen that the mean of all other methods gave 114, and the most trustworthy observations by the dynamometer gave 121 watts. Here, then, was a riddle to be explained. It was only susceptible of two solutions. Either the dynamometer, three-voltmeter, and three-ammeter results for the "Hedgehog" were greatly in excess of the true value of the power absorbed, or else Mr. Swinburne had achieved the marvellous feat of inventing a wattmeter which, whilst reading approximately correctly the power taken up in transformers of good closed magnetic circuit type, measured too little by nearly 50 per cent. when applied in the same way to test his own.

18. It was felt to be necessary to examine this matter with the greatest care. Experiments were therefore made with three small "Hedgehogs" which had been made for lecture purposes. These transformed from 100 to 33 volts. These three little transformers were arranged with their primary circuits (100 volts) in parallel, and with their secondary circuits open. The power taken up in the three together at 100 volts was measured by the three-voltmeter method, the dynamometer wattmeter, and with the Swinburne wattmeter. These experiments were carried out as follows:—In series with the transformers was placed a couple of incandescence lamps as a non-inductive resistance, and three Kelvin multicellular electrostatic voltmeters were employed in a three-voltmeter method to measure the power absorbed in the transformers. The resistance of the lamps was obtained by a measurement of the current passing through the lamps, using either a Kelvin ampère balance or a dynamometer placed behind the voltmeters. With these arrangements, and using a very steady pressure, and such ratios of the potential differences as would give the best results, we obtained 11 measurements of the power absorbed at no load by these three little "Hedgehogs." These results are tabulated in Table XXXI. Then, next, both the Swinburne wattmeter and the dynamometer wattmeter were carefully standardised on an incandescence lamp working at 100 volts; measuring first the true power taken up in the lamp by volts and current, and then using this value to obtain the constant of the wattmeters. The standardised wattmeters were then set to measure the power taken up in the three small transformers. The results are given in Table XXXII.

TABLE XXXI.—*Experiments on Power absorbed by Three Small "Hedgehog" Transformers at No Load, taken by Three-Voltmeter Method at* 100 *volts.*

Current through transformers, in ampères.	Readings of electrostatic voltmeters (Kelvin).			Resistance in series with transformers, in ohms.	Power in watts absorbed by the three transformers.
	V_1.	V_2.	$V_{1,2}$.		
2·02	100	93·6	143·0	46·3	18·2
2·02	100	93·9	143·5	46·5	19·1
2·02	100	94·0	143·0	46·5	17·1
2·02	100	93·9	143·4	46·5	18·9
2·02	100	93·9	143·0	46·5	17·6
2·02	100	94·3	144·0	46·7	19·4
2·07	100	95·2	144·7	45·9	20·4
2·06	100	95·4	144·6	46·2	19·5
2·096	100	95·5	145·0	46·1	20·7
2·092	100	96·7	145·8	46·2	20·5
				Mean power in watts,	19·26

TABLE XXXII.—*Experiments on the Power absorbed by Three Small "Hedgehog" Transformers at No Load, taken by Dynamometer and Swinburne Wattmeter at* 100 *volts.*

(Wattmeters both standardised on an incandescence lamp taking 42 watts.)

Volts on terminals of transformers.	Scale readings of		Power absorbed in watts by the three transformers.	
	Dynamometer wattmeter.	Swinburne wattmeter.	By dynamometer wattmeter.	By Swinbure wattmeter.
100	15·0	28·5	19·1	12·6
100	15·1	28·5	19·2	12·6
100	15·1	28·8	19·2	12·7
			Mean 19·16	Mean 12·61

Collected Results for the Mean Value of Power absorbed by the Three Small "Hedgehogs" arranged in Parallel.

By three-voltmeter method	19·26 watts.
By dynamometer wattmeter	19·16 „
By Swinburne wattmeter	12·61 „

We see that the mean value of the power taken up as measured by the three-voltmeter method agrees quite well with the value obtained by the dynamometer wattmeter, but that the value obtained by the Swinburne wattmeter is nearly 34 per cent. lower than the other two.

These experiments, which were very carefully made, convinced me that the cause of the discrepancy must be looked for in the Swinburne wattmeter.

Mr. Swinburne sent for use with his transformer a condenser suitable for putting upon the primary circuit in parallel with the primary circuit of the "Hedgehog." We therefore applied the two wattmeters to measure the power taken up (1) in the condenser alone, (2) in the transformer alone, and (3) in the condenser and transformer on open secondary circuit when the condenser was joined in parallel with the primary of the transformer. The primary pressure was 2,400 volts in all cases. When the condenser was across the circuit alone, the current flowing into it was 0·458 ampère, as measured by a Kelvin balance. Since the frequency was 83, this shows the capacity of the condenser was about 0·36 of a microfarad. The magnetising current, or open-circuit current, of the 3,000-watt "Hedgehog" was 0·761 ampère; and when "Hedgehog" and condenser were joined in parallel the current flowing into them jointly was 0·283 ampère. The Swinburne wattmeter and dynamometer wattmeter being both standardised, 12 measurements were taken with each instrument—four of the power absorbed in the condenser, four of that absorbed in the transformer with open secondary, and four of the condenser and transformer joined in parallel. The results are given in Table XXXIII.

TABLE XXXIII.—*Experiments on the Power absorbed in Condenser and "Hedgehog" Transformer separately and together, taken by Two Wattmeters at a primary pressure of* 2,400 *volts.*

(*a.*) *Power absorbed in Condenser alone.*

By Swinburne wattmeter.		By dynamometer wattmeter.
44·8 watts.	...	18·0 watts.
44·0 „	...	21·0 „
50·0 „	...	30·0 „
47·0 „	...	27·0 „
Mean ... 46·4 „		Mean ... 24·0 „

(*b.*) *Power absorbed by "Hedgehog" at No Load.*

	By Swinburne wattmeter.		By dynamometer wattmeter.
	41·5 watts.	...	120·0 watts.
	44·0 „	...	120·0 „
	36·0 „	...	108·0 „
	33·0 „	...	112·0 „
Mean ...	39·0 „	Mean ...	115·0 „

(*c.*) *Power absorbed by Condenser and same Transformer in Parallel.*

	By Swinburne wattmeter.		By dynamometer wattmeter.
	96·3 watts.	...	144·0 watts.
	25·0 „	...	144 0 „
	100·0 „	...	150·0 „
	95·0 „	...	140·0 „
Mean ...	96·5 „	Mean ...	144·0 „

It is clear, therefore, that whilst relatively to the dynamometer wattmeter Mr. Swinburne's first wattmeter reads too low on his transformer, it reads too much on his condenser, and he has been overrating the power taken up in the condenser to about the same extent as he has been underrating that taken up in the transformer.

On thinking over these results, it became evident that they could be accounted for on the supposition that the current through the shunt circuit of the Swinburne wattmeter was *advanced* in phase as compared with that of the primary impressed potential difference between the ends of that circuit. The correctness of the wattmeter as a power-measuring instrument depends upon the current in the shunt circuit being exactly in step, or consonance, with the periodic potential difference at the ends of that circuit. When the wattmeter is applied to the open circuit transformer, the current through the transformer, which is also the current in the series coil of the wattmeter, lags behind the P.D. at the primary terminals of the transformer. Hence, if the current through the wattmeter shunt circuit (which should represent that P.D. in phase and magnitude) is advanced in phase, the two currents (series and shunt) in the wattmeter will have a greater difference of phase impressed upon them, and hence the mean product will be diminished. Again, if the wattmeter is applied to a condenser, the current through the condenser is normally in advance in phase of the P.D. at its terminals. Hence, by the same reasoning, any cause tending to advance the phase of the current through the shunt circuit of the wattmeter will bring the shunt and series currents more into step and increase the mean product. Therefore the wattmeter reading will be too little on a transformer and too great on a condenser.

It is obvious that this advancement of phase of the current in the shunt circuit of the wattmeter could be produced by *capacity* in that circuit.

The resistance of the shunt circuit of the Swinburne wattmeter is about 100,300 ohms; of that, the movable coil has 300 ohms resistance, and the 100,000 ohms is the resistance of the doubly wound fine wire in two brass boxes, which are joined in series with the bobbin. Experiments were then made to see if we could, by artificially increasing the capacity of either of these parts of the shunt circuit, exaggerate the defect, and, if so, whether the readings of the wattmeter on the "Hedgehog" were more altered than readings on a non-inductive resistance.

Exp. 1.—A small Leyden jar of 1 pint size, about 0·001 or 0·0005 of a microfarad in capacity, had its inside and outside coatings connected to the ends of the external resistance (in brass boxes) of the shunt circuit. So arranged, the Swinburne wattmeter was applied to measure the power taken up in the 3,000 watt "Hedgehog" on open circuit and in our non-inductive resistance. With the jar removed, the deflection of the wattmeter was 5 divisions, corresponding to about 80 watts taken up in the transformer. With the jar added, the deflection fell to 0·3, or 5 watts. No such change was produced by adding the jar when the power being measured was being taken up in the non-inductive resistance. It is evident, therefore, that capacity added to the shunt circuit still further reduces the wattmeter readings.

Exp. 2.—In order to find out, if possible, whether the prejudicial capacity existed in the external resistance in the brass boxes or in the internal resistance in the movable bobbin of the shunt circuit, the brass boxes were removed and their place taken by a resistance of 34,000 ohms, made up of the filaments of high resistance incandescence lamps. It seemed clear that a row of lamps could have no sensible capacity. The readings of the wattmeter were then compared when the shunt circuit external resistance consisted of 34,000 ohms made up of lamp filaments, and 100,000 ohms made up of doubly coiled wire in brass boxes, being taken both on the 3,000-watt "Hedgehog" and on a 15-H.P. Ferranti transformer. No greater difference was found in the power measurements in the two cases than might be due to errors of reading. For the "Hedgehog" the power reading with the external resistance of lamps was 79 watts, and 81 watts in the case of the wire resistance. For the other transformer values of 125 and 130 watts were found. Hence it appeared to be more probable that the capacity giving rise to this diminished power reading might be due to the small electrostatic capacity of the tightly coiled wire bobbin of very many turns which forms the suspended circuit of the wattmeter, and that this capacity advances the phase of the current in the shunt circuit, so that instead of being exactly in step with the P.D. on the terminals of the transformer it is slightly in advance of it.

Subsequently to the date of the experiments above recorded, Mr. Swinburne sent a second wattmeter of similar character, but differing from the first sent in that it had an ebonite outer case and no metal frame near the movable coil. This second wattmeter was carefully compared with the first one and with our own dynamometer wattmeter. The three wattmeters were standardised, and their constants determined by noting the instrumental readings when the instruments were set to read the known power taken up in the standard inductionless platinoid resistance arranged to absorb 600 watts at a P.D. of 2,400 between its terminals. The so-calibrated wattmeters were then set to read the power taken up in the 3,000-watt "Hedgehog" on open circuit, the Swinburne condenser, the old Ferranti 1,850-watt transformer, the Kapp and Thomson-Houston transformers. The results are given in the table below.

TABLE XXXIV.—*Comparison of Wattmeter Readings on various Circuits.*

Reading of dynamometer wattmeter, in watts.	Readings of Swinburne wattmeters in watts.			Object tested.
	Second pattern.	First pattern.		
		Case on.	Case off.	
600	600	600	600	Standard resistance.
114	106	57	68	3,000-watt "hedgehog."
15	20	46	—	Condenser.
114	99	83	—	Thomson-Houston transformer.
155	154	112	—	Kapp transformer.
303	282	—	—	Ferranti transformer.

It is clear from the above observations that the second wattmeter with ebonite case agrees much more nearly with the dynamometer wattmeter than does the first having a brass case. The differences between the second wattmeter and the dynamometer are quite within the limits of errors of observation, seeing that the instrumental reading for 15 watts is only about 0·5 of a scale division on all instruments. It is evident, therefore, that the second wattmeter sent by Mr. Swinburne is a very different instrument from the first one. The writer is unable to say whether it differs in any way from the first one except in having an ebonite instead of metal case and in having no metal supports near the shunt coil, but it is obvious that the displacement of phase of the shunt current no longer takes place. According to the view above stated, this displacement is the consequence of a capacity effect. It is difficult to see how eddy currents set up in any metal near the movable coil could create the observed defects in accuracy; because, although these might weaken the resultant field in which the movable bobbin hangs and so make the wattmeter readings too low, we have to account also for the fact that the first wattmeter reads too much on a condenser. It is evident, however, that the second wattmeter Mr. Swinburne sent me is a fairly accurate instrument, whereas the first one is quite unreliable on circuits of small power factor.

Before we christen a wattmeter a "non-inductive wattmeter," it should be carefully tested on inductive circuits of small power-factor and large capacity or inductance.

VII.—GENERAL REMARKS ON THE USE OF DYNAMOMETER WATTMETERS TO MEASURE ALTERNATING CURRENT POWER.

The foregoing experiments impressed upon us the necessity for caution in concluding that any wattmeter of the dynamometer pattern, and however made, would give correct readings of the alternating-current power taken up in an inductive circuit. If we consider a simple harmonic current, $\imath$, in, and potential difference, v, at the ends of such an inductive circuit, then the mean value of power, w, taken up in the circuit is $\frac{1}{2} \imath v \cos \phi$, where $\imath$ and v are the maximum values during the period, and ϕ is the phase difference of $\imath$ and v. If ϕ varies, then the rate at which the measurements of the power, w, is varied is expressed by $d w / d \phi = - \frac{1}{2} \imath v \sin \phi$, and the ratio of $d w / w$ is therefore equal to $- \tan \phi \, d \phi$. Hence a small change in ϕ produces a greater effect on the value of the error in measuring the resulting power in proportion as ϕ increases from 0° to 90°.

In the case of an open-circuit transformer there is a very considerable difference of phase between the primary current at no secondary load and the difference of potential between the primary terminals.

Accordingly, if a wattmeter of the dynamometer type is applied to measure the power being taken up in such a transformer at no load, there is a correspondingly great difference between the phases of the currents in the shunt and series coils of the wattmeter. If, then, either by reason of capacity or inductance in the shunt circuit, the phase of the shunt current is displaced by a small amount, the percentage change so introduced into the mean product of the currents —*i.e.*, into the wattmeter reading—is much larger than if the instrument was being used on a transformer of large power-factor.

Hence in the employment of such a wattmeter it is desirable that the movable part of the shunt circuit should have very few turns, and that all metal framework near it be avoided. Generally speaking, it will then be difficult to bestow upon the shunt coil sufficient magnetic moment unless the current in it is comparatively large. This means that considerable power will be dissipated in the wattmeter itself. It is better, however, to employ a wattmeter which uses up a few horse-power and obtain accurate results with it, than reduce its shunt current to a small value and introduce sources of error. It is as necessary to avoid capacity as to annul self-induction in the shunt circuit. As to the external non-inductive resistance in series with the shunt coil, we have, as seen, always preferred to employ a series of incandescence lamps. There is no difficulty in doing this when the

means exist for keeping the P.D. between the primary mains constant. Large circuits of incandescence lamps in series are, however, rather unwieldy and expensive. I have been experimenting lately with other methods to obtain the necessary non-inductive resistance for the external shunt circuit of the wattmeter cheaply and in a compact form. The conclusion arrived at, however, is that, with proper precautions, a suitable dynamometer wattmeter is a very useful instrument to employ for measuring in a practical, workshop-like way the power being taken up in inductive circuits, and that it is much more easy to manage than any of the many other complex methods which look so well on paper and are so difficult to carry out satisfactorily in real life. In any case, a practically non-inductive metal wire resistance is necessary wherewith to standardise the wattmeter *in situ* and before use; and if the movable coil has very few turns, and no metal near it, and the external shunt circuit is of proper kind, excellent results in measuring alternating-current power may be obtained with it.

VIII.—Experiments on the Magnetic Behaviour of Transformers at the Moment of Connecting them to a Circuit.

More than fourteen months ago I carried out a series of experiments and observations on the behaviour of transformers at the moment of switching them on to a "live" circuit, and which are, I venture to think, of some practical importance. They arose out of facts which came to my notice regarding instances of sudden failure of transformers at the instant of closing the primary switch. Transformers have been known to be pierced or to break down on switching on after having worked well for a long time. To investigate the behaviour of transformers at the moment of closing the primary switch and connecting them to a high-pressure "live" circuit, the following experiments were tried:—

Exp. 1.—The secondary circuit of a 4 inch spark induction coil (kindly lent by Mr. Apps) was closed by a vacuum tube of a very sensitive kind. It had long overlapping platinum electrodes. The ordinary primary coil with iron core was removed, and its place filled by a bobbin of 12,000 turns of insulated copper wire wound on a wooden core. This primary coil could be slid into or out of the secondary coil. The primary coil was placed in series with the primary circuit of a 40 H.P. transformer, the "magnetising current" of which was 0·137 ampère. When the transformer had its secondary circuit open, this magnetising current in the primary flowing through the primary coil of the induction bobbin just sufficed to keep up a glow, visible in the dark, in the vacuum tube. The primary coil of the induction bobbin was then withdrawn from the secondary until the glow in the tube just disappeared. Under these circumstances the vacuum tube was an exceedingly delicate detector of any sudden increase in the primary current. If the primary circuit of the transformer was then suddenly and frequently opened and closed by a switch, it was found that at intervals, on some occasions of closing the primary switch, the vacuum tube flashed up brilliantly, thus showing that a rush of current far exceeding the normal magnetising current took place into the transformer on some occasions when the primary switch was closed.

Exp. 2.—Another way of detecting this rush of current is to insert in the primary circuit of the transformer an incandescent lamp, which is brought to proper incandescence by the normal magnetising current of the transformer. Thus, in one of our experiments, a 10-candle incandescent lamp, taking 0·33 ampère, was placed in the primary circuit of a 5-H.P. transformer, the magnetising current of which was 0·35 ampère. When the secondary circuit of the transformer was left open and the primary switch suddenly closed, on most occasions the lamp came quietly to normal incandescence; but on some occasions, on closing the primary switch, the lamp flashed up brilliantly, so much so as to blacken the glass, and in some cases even to break the filament. This experiment showed in a striking manner the sudden rush of current into the transformer on closing the primary switch.

Exp. 3.—In another experiment, a Kelvin centiampère balance was inserted in the primary circuit of a 40-H.P. transformer, of which the normal magnetising current was 0·137 ampère. The balance was adjusted so as to be in equilibrium when this current was passing, and the primary current was then switched on frequently. On some occasions the balance was thrown up violently, even when the weight was moved into positions corresponding to 5 or 10 ampères. In one case, the weight being at the position corresponding to 10 ampères on the balance, the balance was thrown up violently at the third switch-on. On other occasions, the weight being at the position corresponding to 10 ampères, the balance was thrown up at the 5th, 11th, and 13th time of switching on, whilst on the other occasions it was not moved. In one instance the beam of the balance was thrown up so violently that the weight, having a mass of about 66 grammes, was completely thrown off the scale pan; thus indicating that on that occasion an immense rush of current passed in the transformer at the moment of closing the primary switch, but which current sank again almost instantly to the steady value of 0·137 of an ampère.

Exp. 4.—The safest and by far the most convenient method of showing this rush of current was found to be the employment of a simple form of dynamometer placed in the primary circuit. Two flat coils were constructed of No. 20 covered copper wire, each coil having 23 turns coiled up as a sailor coils a rope, the external diameter of the coil being 5½ inches. These flat coils were suspended by silk ribbons on a vertical plane, facing one another. The coils had straws cemented to them, which hung down like the leaves of a gold-leaf electroscope. By means of flexible connections, the primary current of the transformer could be passing through both coils in series in such a direction that the coils tended to repel one another when the current was passing. The weight of the coils was such that when the normal magnetising current of the transformer was passing the repulsion was hardly visible. On switching on and off the primary current a great many times, on certain occasions the coils were widely apart, so that the straws, which were about 8 inches long, diverged from one another like the leaves of a gold-leaf electroscope when an excited glass rod is brought near them; the divergence being such as to cause the tips of the straws to separate about 6 inches. This arrangement could be conveniently inserted in the primary circuit of any transformer, and adjusted so as to show the sudden rush of current on some occasions when the primary circuit was closed.

Exp. 5.—On those occasions when the sudden rush into the transformer took place, a violent thump, or knock, was heard in the transformer. The suggestion was made by Mr. Partridge to employ a wooden rod pressed against the transformer in order to listen to the internal sounds. Accordingly, a transformer stethoscope was constructed, consisting of a rod of deal with a piece of ebonite on one end and a circular disc of pine on the other. By pressing the ebonite against the iron core of the transformer and putting the ear against the wooden disc, it was found possible to study these internal noises in the transformer. On listening to the character of the sound made on switching on a transformer, it was found that on some occasions there was hardly any noise; on others, a slight knock, or thump, or loud tick; and on others, a still more violent noise; and the violent noise always occurred when the other appliances showed a sudden rush of currents taking place into the transformer. It is clear, therefore, from these experiments that something peculiar happens on some occasions on closing the primary switch of a transformer having an open secondary circuit, at the moment when the primary current is connected to the "live" circuit. On considering the matter carefully, it became evident that the conditions under which the transformer is disconnected from the circuit must determine what happens when the transformer is re-connected to the circuit. If the current is flowing into the primary circuit of a transformer, and the switch is opened, as long as the arc continues at the switch, so long does the alternating current produce in the iron core an alternating magnetism; but, at some instant, the arc breaks suddenly, and the primary current is then interrupted. The transformer, therefore, is left magnetised in some particular phase—either strongly magnetised one way or the other, or, perhaps, not magnetised at all, depending on the phase of the current when the current finally ceases. It is clear that on switching on the current again the switch must be closed in some particular phase of the pressure, and that, therefore, the in-coming current finds the iron of the transformer already in a magnetic condition. It may be that the magnetism of the iron is in such a direction that the current is able to produce instantly the necessary counter electromotive force to keep down the current to its normal mean value; but it may be that the magnetism of the core is in such a direction that the first change which takes place in the magnetic condition of the core is one which, so far from introducing a back electromotive force into the primary circuit, actually assists the current. In other words, the self-induction of the transformer is non-existent for the first moment, and until the current has got the core into proper magnetic condition, in proper relative step with itself, there is not sufficient impedance in the primary coil to prevent the impressed electromotive force making just whatever current it can, so far as the true, or "ohmic," resistance of the primary circuit will allow. Under these conditions, therefore, it is evident that there must be a great rush of current into the transformer, until the impedance is built up by the magnetism of the core falling into proper relative step with the current.

Exp. 6.—It was considered advisable to find out whether this sudden rush of current into the transformer was accompanied by an increased potential difference between the primary terminals of the transformer; accordingly, the induction coil and vacuum tube employed in Experiment 1 were arranged so that the primary circuit of the induction coil was in series with a non-inductive resistance placed across the primary mains, in parallel with the primary circuit of the transformer. It was expected that if a rise of pressure took place on switching on the transformer, the vacuum tube would indicate it by flashing up; but the experiment failed to indicate any rise of pressure, even when the primary coil of the induction coil was adjusted as carefully as possible to show any increase in pressure between the primary mains.

Exp. 7.—The following method was then tried:—Two brass balls, about 1 centimetre in diameter, carried by horizontal screws, having 24 threads to the inch, passed through fixed nuts on an insulating stand. One of these screws had a large divided ebonite head, or arm, to serve both as a handle and an index. This discharger was placed in series with a primary fuse across the primary mains, in parallel with the transformer. The balls were then screwed up until just in physical contact, and afterwards separated by such a distance that the alternating pressure employed between the primary mains—namely 2,400 volts—could just spark across the distance. This sparking distance was found to be about three-quarters of a millimetre. Having determined this sparking distance, the balls were further separated by such a small amount as just to prevent the normal pressure from sparking across. This arrangement being kept in parallel with the primary circuit of the transformer, the primary current was then switched on and off a good many times, and on some occasions the spark jumped across the spark balls at their increased distance, thus showing an increase of pressure. The greatest distance between the balls across which the spark was found capable of jumping was 0·84 of a millimetre. Other experiments were made to determine what alternating pressure would jump across this increased distance. It was found to be something not exceeding 4,000 volts.

The above experiments were varied in many ways, but they all went to prove that at the instant of switching the transformer with an open secondary circuit on to the primary mains, a sudden rush of current may take place into the transformer, and a sudden rise of pressure at the terminals of the transformer.

Exp. 8.—It was deemed advisable to ascertain whether the

rush of current into the transformer was a continuous rush—that is to say, a rush all in one direction, lasting over a certain fraction of a second—or whether it was an alternating rush—that is to say, a great increase of current, but at the same time maintaining the normal alternations. In order to settle this point, the flat coils before described in Experiment 4 were arranged so that the primary current of the transformer flowed through one coil, whilst the other coil was traversed by a continuous current produced by a secondary battery. If the rush of current into the transformer is a current always in the same direction, lasting a sensible fraction of a second, it was thought probable that a repulsion would take place between the two coils, one traversed by the steady current, and the other traversed by a current into the transformer; but no such repulsion was found under any circumstances.

It seems probable, therefore, that this rush of current is an alternating rush, and that it is simply due to the fact that until the magnetisation of the core has settled down into the proper condition, the impressed alternating electromotive force produces whatever current it can through the primary coil, being only limited in so doing by the true resistance of the primary coil.

Exp. 9.—It was considered important to ascertain how this rush into the transformer could be prevented. It is obvious that it can be entirely destroyed by inserting a sufficient non-inductive resistance into the primary circuit, which is gradually removed in place of suddenly closing the switch.

A better method, however, was suggested by Mr. Reginald Brougham—that is, to wind on the transformer a small tertiary circuit. This tertiary circuit is made to take current from another small transformer, which is kept in permanent connection with the primary main, and by means of which the core of the transformer to be connected is magnetised in the proper manner, and in the proper direction for producing instantly the necessary opposing electromotive force in the primary circuit when the primary switch of that transformer is closed. When this is done, there is never any "bang," or sudden current-rush, on closing the primary switch of the transformer under test. As a matter of fact, it has been found that when a bank of transformers is being fed from one primary circuit, and feeding their secondary currents into one secondary circuit, then, provided that one of the transformers of the lot is kept connected both to the primary and secondary sides, it is amply sufficient to proceed in the following manner in connecting in other transformers, in order to obtain perfect immunity from any harmful rush of current:—The transformer to be connected to the circuit is connected first on the secondary side, and although this process does produce a rush of secondary current back into the transformer, yet, nevertheless, the rises of pressure that take place never seem to be very serious. The transformer core being thus magnetised in proper relative step with the primary pressure, the primary circuit can be closed, and under no conditions then will there be any sudden rush of current into the transformer.

Exp. 10.—Many experiments were tried to find out what was the minimum resistance necessary to prevent this rush in the various sizes of transformers. It is obvious that a switch which closes the primary circuit, first by inducing resistance, and then gradually removing it, will sufficiently prevent any obnoxious rush of current into the transformer, because the impressed electromotive force is held back, as it were, by the additional resistance from producing excessive current until the magnetism of the core has had time to fall into proper step.

Exp. 11.—Many effects due to similar causes can be produced in open magnetic circuit transformers. In switching off an open-circuit transformer, such as the "Hedgehog," when the secondary of the transformer is on open circuit, a very strong arcing is sometimes observed at the switch; and the shorter the magnetic circuit of the transformer, the worse does this effect become.

On one occasion I had brought to my notice an experimental transformer of an open-circuit type, the iron core of which was remarkably short in comparison with its width. This transformer had a remarkable property—that after having been connected to the primary circuit, it could not be disconnected as long as the secondary circuit of the transformer was open, without making an immense arc at the switch.

The rough explanation of this fact appears to be as follows:—In the open magnetic circuit transformer, especially if the iron part of the magnetic circuit is very short, the average value of the rate of change of induction or of the back electromotive force decreases much more rapidly as the mean value of the current decreases than is the case in closed magnetic circuit transformers. Hence, when in the case of the first-named transformer, the primary switch is opened, the immediate reduction of the primary current-strength removes the greater part of the back electromotive force, or opposing counter electromotive force of induction, and greatly increases, therefore, the resultant electromotive force in that circuit. An arc, therefore, continues to follow the switch points as they open, for a considerable distance. In the case of the closed magnetic circuit transformer this is not the case. The initial reduction of the current strength as the primary switch opens is not accompanied by so great a reduction in the mean rate of change of the induction, and, therefore, of the back electromotive force. The resultant electromotive force in the circuit does not, therefore, rise much, and the switch points are soon beyond the distance at which an arc can be maintained.

Such an arcing can be subdued in the case of a very short iron magnetic circuit transformer by closing the secondary circuit. The mutual induction of the circuit then assists in creating a greater back electromotive force in the primary circuit, and so keeps the resultant electromotive force small as the switch points open.

There are several effects of this kind observable in the process of connecting or disconnecting large condensers to or from high-pressure alternating circuits. There is, in fact, always a risk of breaking down large condensers at the moment of putting them on or off alternating current circuits, and this appears to be connected with a peculiar behaviour of an alternating current arc between metallic surfaces, in virtue of which it acts like a resistance of large self-induction.

CONCLUSION.

There are very many derivative matters which, if space permitted, might be discussed as consequences of facts observed in the course of the above-described researches. It is evident, for instance, that the last word has by no means been said on the subject of the design of transformers. I have every hope that before long transformer manufacturers may be able to produce transformers of 25 H.P. and upwards having close upon 90 per cent. efficiency at one-tenth of full load. When that is done, it will be interesting to repeat some of those calculations which have already been made as to the relative cost of delivering a certain number of thousand units on an average load diagram, say for distances of 1,000, 2,000, 3,000 yards, &c., by low pressure feeders, and by high pressure plus transformer feeders. Calculations of this kind can be made with some degree of confidence now that it seems clear that the iron losses in transformers are constant at all loads, and that there is a definite relation between this loss and the open circuit, or magnetising, current. We can hardly regard the great controversy of open *versus* closed magnetic circuits as entirely and definitely settled, but there is no reason to believe that the majority of those who have designed transformers with closed magnetic circuits have been supremely unwise in their faith or in their works.

In the matter of transformer testing, the experience gained in obtaining the facts brought before you has established in the writer's mind, at least, the feeling that a properly constructed dynamometer wattmeter is perhaps the best workshop instrument to use for this purpose, but that its personal character must be strictly examined before trusting too implicitly to the results obtained by it.

In conclusion, it will only be right to make mention of those who have assisted me in the somewhat arduous work of taking the observations here recorded. The principal share of this has been borne by my assistant, Mr. Shields, who has worked with great perseverance and care for many months in taking the actual observations, and this in many cases required some painstaking work. He was assisted at intervals by Messrs. J. and D. Morris, students in University College, London, especially in those observations in which the careful simultaneous reading of several instruments was required. The observations on the sudden rush of current into transformers were made for me by Mr. Wordingham.

The facts and measurements thus obtained have in all cases been sifted and repeated with the greatest possible care, with the desire to arrive at conclusions which should be worthy of confidence, and useful to those engaged in transformer manufacture and design.

NEW PATENTS—1892.

22,760. "Improvements in the method of and apparatus for electrolysing aqueous solutions of salts." J. A. HEAP. Dated December 12th.

22,826. "Improvements in or relating to the construction of electric accumulators." W. P. THOMPSON. (Communicated by the Süddeutsche Elektricitäts-Gesellschaft, Raab and Bastians, Commandit Gesellschaft, Germany.) Dated December 12th.

22,837. "A combined knocker and electric bell contact." G. S. HOOKER. Dated December 12th.

22,838. "Improvements in long distance telephones." C. A. DAY. (Communicated by C. M. Haynes, United States.) Dated December 12th. (*Complete.*)

22,843. "Improved application of aluminium and its alloys." W. R. TAYLOR. Dated December 12th.

22,854. "A new or improved electric arc lamp." H. PIDOT. (Communicated by P. Archat, France.) Dated December 12th.

22,858. "An improved electric arc lamp." G. DAVENPORT. Dated December 13th.

22,889. "Improvements in electrical fittings, also applicable to other purposes." A. FIRTH and G. Y. ASHWELL. Dated December 13th.

22,914. "Improvements in printing telegraphs." W. L. WISE. (Communicated by C. L. Buckingham, United States.) Dated December 13th. (*Complete.*)

22,915. "Improvements in printing telegraphs." W. L. WISE. (Communicated by C. L. Buckingham, United States.) Date December 12th. (*Complete.*)

22,923. "Improvements in or relating to electric cables." S. Z. DE FERRANTI. Dated December 13th.

22,925. "Improvements in long distance telephonic transmitters of, and receivers of, sound." R. H. COURTENAY. Dated December 13th.

22,931. "Improvements in printing telegraphs." W. L. WISE. (Communicated by C. L. Buckingham, United States.) Dated December 13th. (*Complete.*)

22,947. "A new or improved method of utilising waste energy in water supply systems for generating electricity." W. LOWRIE. Dated December 13th.

22,950. "An improved galvanic dry battery or cell, and a composition for use in such cells." R. HADDAN. (Communicated by R. Gabarro, Spain.) Dated December 13th. (*Complete.*)

22,951. "Improvements in switchboards for use in the distribution of electrical energy." R. E. B. CROMPTON. Dated December 13th.

22,958. "Improvements in lightning arresters." W. R. GARTON and J. C. DANIELS. Dated December 13th. (*Complete.*)

23,007. "Improvements in galvanic batteries." W. WALKER and F. R. WILKINS. Dated December 14th.

23,022. "An improved loud speaking telephone." A. GRAHAM. Dated December 14th.

23,023. "An improved system of telephonic news transmitter." T. PUSKAS. Dated December 14th.

23,039. "Improvements in electrical connections or means for supplying current to electric motors." W. VON WINKLER and J. FEKL. Dated December 14th.

23,051. "Improvements in galvanic dry cells." E. A. MITCHELL and G. T. TUGWELL. Dated December 15th.

23,054. "Improvements in medical and other electric induction coils." J. W. DAVIS. Dated December 15th.

23,057. "Improvements in fittings for use in electric light installations." F. KING and W. P. MENDHAM. Dated December 15th.

23,061. "Improvements in or connected with portable electric lamp fittings." W. H. STURGE. Dated December 15th.

23,068. "Improvements in mechanical and electrical interlocking of railway signals, signal or other levers, and block telegraph instruments, commonly called lock and block." A. ROSS, T. WHARMBY, and R. S. HAMPSON. Dated December 15th.

23,086. "Improved arrangement for communicating by telephone between several stations." R. D. SMILLIE. Dated December 15th. (*Complete.*)

23,101. "New primary batteries." C. A. J. H. SCHROEDER and H. E. R. SCHROEDER. Dated December 15th.

23,113. "Apparatus for determining differences between the phases of two electric alternating currents of like number of alternations." M. VON DOLIVO-DOBROWOLSKY and the Co. ALLGEMEINE ELEKTRICITATS GESELLSCHAFT. Dated December 15th. (*Complete.*)

23,158. "Improvements in electrical meters." P. E. SINGER. Dated December 16th.

23,159. "Electro-mechanical depth indicator." A. R. G. BEAL. Dated December 16th.

23,185. "Improvements in and connected with alarm clocks and electric sound signalling appliances." W. FIELDER and H. NEWMARCH. Dated December 16th.

23,218. "An electric mechanism or device for operating valves." J. WAGNER. Dated December 16th.

23,231. "Method of affecting in electric glow lamps an air-tight union between entering wires, made of non-precious metal and the glass globe." P. SCHARF. Dated December 16th.

23,232. "Improvements in and relating to secondary or storage batteries." J. Y. JOHNSON. Communicated by A. M. Michel, France.) Dated December 16th. (*Complete.*)

23,269. "Varying price electric supply meter." J. PERRY, M. B. FIELD and L. J. STEELE. Dated December 17th.

23,290 "Improvements in alternate current motors for single and polyphase electric currents." E. ARNOLD. Dated December 17th.

23,295. "An improved centrifugal device for opening or closing an electric circuit." Sir D. L. SALOMONS. Dated December 17th.

23,314. "The automatic electric fire alarum." E. F. COX. Dated December 17th.

ABSTRACTS OF PUBLISHED SPECIFICATIONS, 1891.

The Price of all Specifications (old and new) is now 8d. each.

3,984. "Improvements in and relating to electric arc lamps." O. PATIN. Dated March 5th. Comprises a solenoid placed in derivation at the terminals of the arc which acts upon a small cylinder of soft iron, and thus causes the ascending or descending movement of this cylinder. Through the medium of mechanism, this movement of the cylinder is transmitted to the carbons, which approach or recede from each other according as the electromotive force augments or diminishes. Prior to the operation the carbons are separated in the lighting, the current passes through the coil alone, the core is attracted, a brake is relaxed, and the carbons come in contact. At the moment when the current flows entirely through the carbons, the core descends again and causes the separation, that is to say, the lighting. 6 claims.

4,669. "Improvements in machines for generating electricity." V. HIBBEC. Dated March 16th. Relates to a frictional machine. 7 claims.

4,682. "Improved means for securing safety in electrical supply systems." S. Z. DE FERRANTI. Dated March 16th. The inventor employs a fuse wire which may be coupled at its centre to earth, and placed in series between two impedence or resistance coils placed as a shunt across the poles of the circuit to be protected, to normally retain out of action contact apparatus, which when allowed to come into action short circuits the poles of the circuit, and puts them to earth, and may at the same time actuate a throw-off switch to disconnect from the supply mains. 12 claims.

4,684. "Improvements in instruments for measuring and adjusting magnetic force." W. MAYES. Dated March 16th. Claims:—1. An instrument for measuring magnetic force, consisting of a case with a transparent lid, having a line or lines diametrically across the face, a pivot within the said case, and a magnetic needle adapted to turn upon the said pivot and also about a horizontal axis in a vertical plane, the said needle having means for adjusting its balance. 2. In such an instrument for measuring magnetic force, a needle having a pivoting cap pivotably attached to it, so as to allow the needle to rotate about a horizontal axis in a vertical plane, and a balance weight or weights mounted as nuts on screwed supports on the needle, substantially as described. 3. In such an instrument for measuring magnetic force, a needle as claimed in Claim 2, in combination with a graduated ring around the case, within which the needle is pivoted, and a transparent cover having lines diametrically disposed across its face, substantially as described. 4. The construction and arrangement of an instrument for measuring magnetic force, substantially as described and illustrated in the drawings.

6,048. "Improvements in electric power apparatus." G. NORTH. Dated April 8th. Consists in introducing between the armature and the load, preferably in or upon one of the shafts conveying the power, a friction or similar clutch or relief device, whereby, should the load become excessive, the armature spindle will slip round, and thus the armature itself will be saved. 3 claims.

6,489. "A combined ceiling switch, cut-out, and ceiling rose for electric incandescent lamps." W. R. PRYKE. Dated April 15th. The object of this invention is to construct an electric switch, an electric cut-out, and a ceiling rose in a combined form, so that the switching can be effected by a pull on a cord, or wire, like as by a bell pull and a lift, or return of the pull cord to permit of the current being switched off. 2 claims.

8,457. "Improvements in electric arc lamps." G. A. SPOKES. Dated May 16th. Consists in the combination of a break with a governor or pallet arrangement which works in a tooth wheel on the side of which is a flange; upon this flange is a rubber or break, which is tightened thereon by a spring or weight, and is released by the pressure being taken off when the arc is too long, by the rubber of part to which it is attached being actuated by magnetic attraction or repulsion. 1 claim.

9,227. "Improvements in telephones." SIEMENS BROS. & Co., LTD. (Communicated from abroad by Messrs. Siemens and Halske, of Berlin.) Dated June 1st. Consists, mainly, in mounting the iron membrane on a shallow box or cup-shaped casing of thin brass, so as to form, as it were, the lid of the box. The short elbow-shaped flat electro-magnet cores are fixed on a flat angular steel magnet, which is either so magnetised as to have two diametrically opposite poles, or which is constructed of two semi-circular magnets placed with their poles opposite each other. This permanent magnet is attached to the bottom of the box with the intervention of a disc or layer of non-elastic material, such as vulcanite, celluloid, soft lead, &c., which prevents the transmission of sound vibrations from the box and the magnet, and which is so fixed as to determine the exact position of the poles of the electro-magnet relatively to the membrane. 3 claims.

CORRESPONDENCE.

High Pressure Steam Generators.—Mr. Thwaite's Reply.

Your critic admits, in addition to the list of admissions of defects enumerated in my last letter,

1. That the chief stresses of a Lancashire type of boiler are due to the flat end plates, and he actually makes the assertion that this form is a concession to appearances, and suggests that a remedy for this defective feature would be in the making of the ends hemispherical. I should like to see the effect of such a suggestion on the risible nerves of a practical boiler maker.

Perhaps your critic will explain how, or in what way, he would attach the internal furnace flues to these hemispherical surfaces.

No, Mr. Critic; you may have been born inside a Lancashire boiler, and lived some thousands of hours inside them, but your critical faculties were during this period not very wide awake.

Boiler-makers, when they construct a shell boiler, externally fired, make the ends an approach to the hemispherical form—this your critic will admit if he examines the type of boilers used in blast furnace gas-fired steam boiler practice.

2. He says, "grooving of end plates and angle irons is not due to unequal expansion, but to alternate expansion consequent on *unequal* temperature of furnace;" he admits *inequality* of temperature, so that the logical consequence must be *unequal expansion*, because one is a *direct function* of the measure of the other. It is, of course, admitted that by steady mechanical firing, this inequality of temperature "may be reduced, but it is at the period of initial lighting up, and during the period of heating up the water to 100° C.

that the maximum stress due to unequal temperatures of boiler structure is produced. The lower inverts of boiler flues beneath the grates is kept cool by the inflow of cold air on one side, and cold feed-water on the other, whilst the crown of flue is subjected on one side to the contact with violent combustion, and mechanical firing is no remedy for this.

My contention is that the part of the structure of a steam generator subjected to this violent and fluctuating action of combustion, such fluctuation being the consequence of the varying proportion of the hydro-carbon of the fuel, should be of a flexible character, and in my own steam boiler designs the nest of small-bore water-tubes are so curved in outline, that they freely expand and contract without setting up serious stresses in the steam-holding part of steam generators.

I concede that the neutralisation of the water by the addition of an alkaline, may reduce the tendency to the setting up of electrolytic action, but I consider that a better remedy is the rapid circulation of the water.

We are in accord in that the structural details of the 1866 type of boiler were defective, but, he asks, "What can be wrong in a boiler shell of circular cross-section? No objection has been raised against the geometric form, that is if the shell could be welded instead of riveted, and if the plates were subjected to equal temperatures; but this is not done, and there is an objection to this large diameter shell compared with one of smaller diameter, in the fact that for the coming high boiler pressures of 300 pounds to the square inch, the large diameter of shell involves an abnormal thickness of plate, and the difficulties due to expansion are intensified, besides the laminæ structural stress set up and due to the bending of the abnormally thick plates and plated joints.

Let my critic compare the thickness of the metal required to safely withstand the pressure of 300 pounds, with a shell diameter of 8 feet to 12 feet, with that required for the shell diameter of say 3 feet 6 inches of my steam steerage drum.

He says that what is wanted is not long steam storage space, but large water storage. This is rather a vague expression. What is meant by large? I contend, with all deference, that the water storage space should be a function depending upon the efficiency of the heating surface, and as long as there is an excess of steam production over that required for the industrial process, this is all that is required.

The factor of heat storage volume should depend upon the ratio of a unit of heating surface to its effective evaporative efficiency, and I think that measured on this basis, it will be found that the small water tube steam generator gives as adequate a reserve of heat or thermic potential as does a Lancashire or Cornish boiler.

Your critic considers that American engineers are very conservative. I wonder if he could find a single advocate in favour of his views. I have met many trans-Atlantic engineers, and without exception they were all distinctly progressive and readily absorptive of new ideas—having a rational *raison d'être*. The single exception quoted by my critic only proves the rule. What is this trivial evidence of rational caution? Compared with records that I could draw up describing the innovations in railway engineering procedure and management, compare *inter alia*, railway management in the States with the mismanagement pointed out in the pages of the ELECTRICAL REVIEW, of our English lines—to whom have we to thank for the changes of rolling stock now being creepily adopted by English railway men? I refer to the Pullman car, the corridor coaches, the Westinghouse and vacuum breaks, and the centre spring buffer coupling. Echo answers, "American progressive engineers." And in railway bridge work they have given us a lesson that lightness of structural work may be compatible with physical strength, although here I am ready to admit that they have carried the principle in many instances too far, forgetting that, as proved by my formulæ for corrosion,* that oxidation may step in and reduce the fine margin of safety down to nil in a short time, besides the altered molecular metallic structure that may follow continued vibration.

My critic wishes to emulate Macquorn Rankine in developing the area of application of mathematical forms or deduction, but he is less happy than that illustrious scientific engineer. When the equation is tested in the manner drawn up by my critic, and the results are what he prognosticates, I shall then, and not until then, admit his claim by incidence of literary superiority. My critic claims equal experience with myself in the difficult science of fuel combustion; as he apparently does not know the extent of my experience, such a claim is groundless. I am, however, positive, judging from the views he holds, that except as the possible handler of a coal shovel a few times, his practical knowledge of fuel combustion is a very uncertain quantity. I contend that once gaseous fuel of any character—crude or purified—is intimately mixed with air in adequate chemically equivalent proportion, and simultaneously with, or prior to ignition, that the result will be absolute and smokeless combustion, and although I have not proved this some *hundreds or thousands of times*, I have had sufficient experience to be able to make the statement with positive confidence. As my critic writes under the mask of anonymity, he can make statements as to experience, and can put on condescending airs of expression, without fear, but I am bound to say that although the anonymous critic has a right to criticise, he has no right to lay claim either to superiority of diction, or to superior experience, and the sooner our technical journalists take a leaf from French technical and scientific journalistic practise, the better for fair play in the literary or controversial duello. In French journals criticism, whether editorial or in the form of reviews, is generally published under the shadow of the writer's name. I am glad to see that this procedure is already being adopted by some of the English journalists. Anonymous criticism is un-English—and I regret to say—very often unscrupulous. I do not wish these remarks to apply to my critic, because he is probably not responsible for his anonymity; indeed, it may be, that he is suffering an injury, because by the publication of his name his claims of superior and equal experience might not be requisite; his name alone would be looked up to with the awe and respect commanded by immeasurable eminence above our state of scientific mediocrity, literary imperfection, and inexperience.

Referring to his remarks on the two designs of steam boilers, both types will have a refractory line combustion chamber and perforated arch, so as to enable the gaseous fuel and air to be thoroughly intermixed before or preceding ignition.

Now with reference to the final part of my critic's letter. I am quite willing to admit that had I seen the insides of hundreds or thousands of boilers—in fact the number is an unknown quantity—which my critic lays claim to have seen, I might then recognise some of his objections to the small bore water tube type of steam boiler, but I am convinced that no amount of mere outside observation will displace the opinion I still hold, and which is fully justified by my critic's own actual admissions, *i.e.*, that the Lancashire, Cornish, and the marine boiler (return tube type) are bad in their fundamental design.

In bidding my critic good bye for this year of 1892, I wish him all happiness in the dying hours of this old year.

B. H. Thwaite.

December 26th, 1892.

* *Vide* p. 32, "Molesworth's Pocket Book," Engineering Formulæ, xxii., Ed. 1882. Equation to determine the corrosion of iron and steel.—B. H. Thwaite.

Raising Mercury.

In your issue of October 28th, I notice a letter from Prof. J. Smith on "Raising Mercury." He there says that "the height to which mercury can be raised by the use of a vacuum is obviously limited to the barometric pressure."

It will, therefore, be a surprise to Prof. Smith and others to hear that I am working with a mercury pump, in which the supply is raised on a modified or rather carefully worked out "von Babo" principle." This pump is permanently attached to a mechanical vacuum pump, and raises its own mercury supply without the use of any taps or timed valves, and (with the single exception of opening one tap on beginning to exhaust a fresh batch of lamps) works quite automatically and raises its supply of mercury *over* 1,600 *mm.*, which is considerably above 760 mm., the barometric pressure.

C. J. Robertson,

Technical Director Electrische Glühlampen Fabrick "Watt" Vienna.

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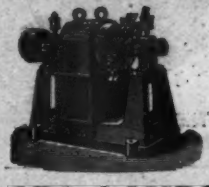

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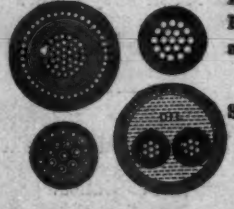

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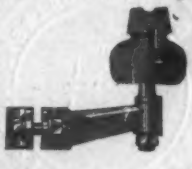

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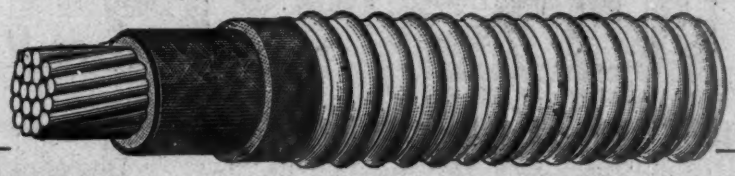

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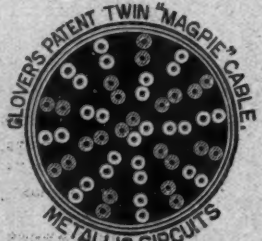

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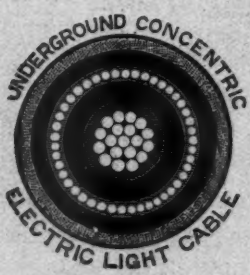

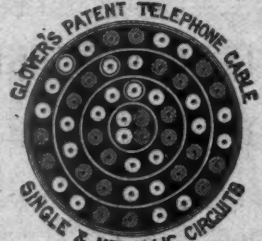

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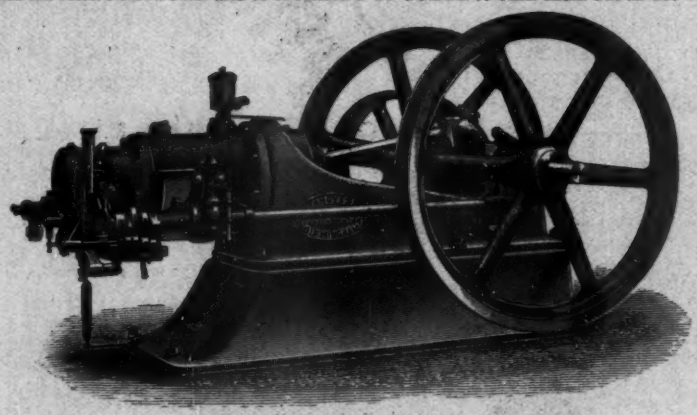

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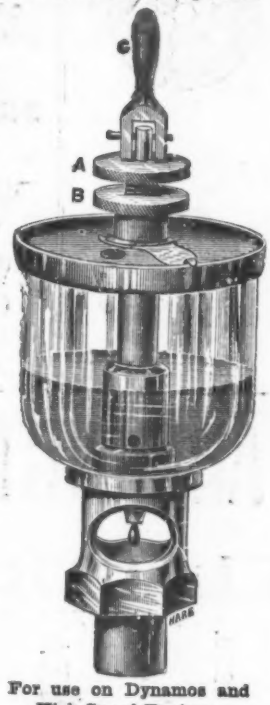

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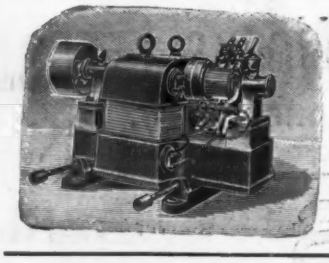

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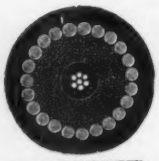

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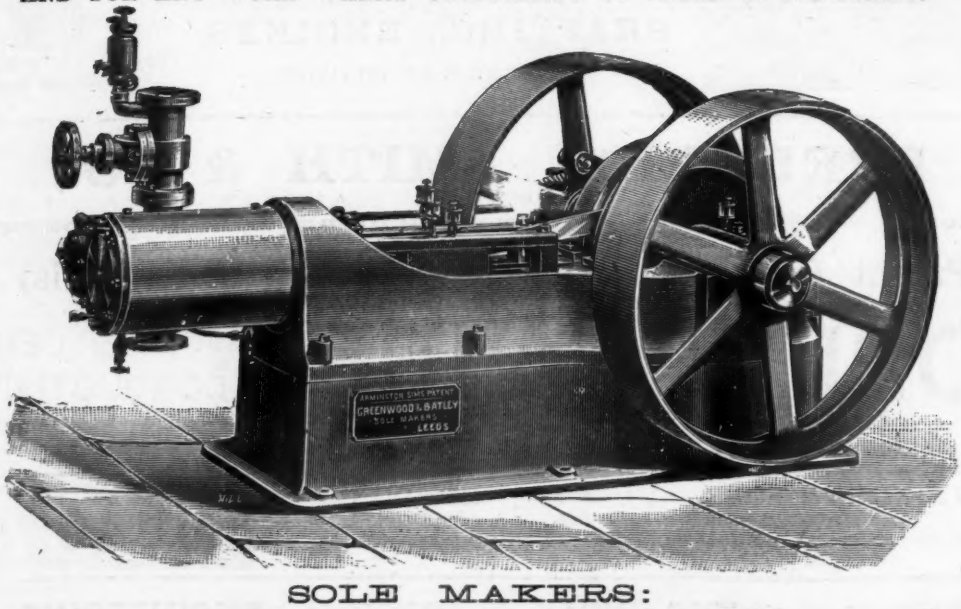

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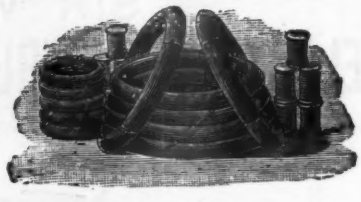

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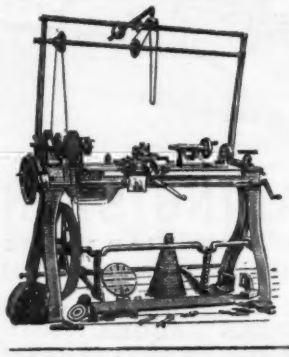

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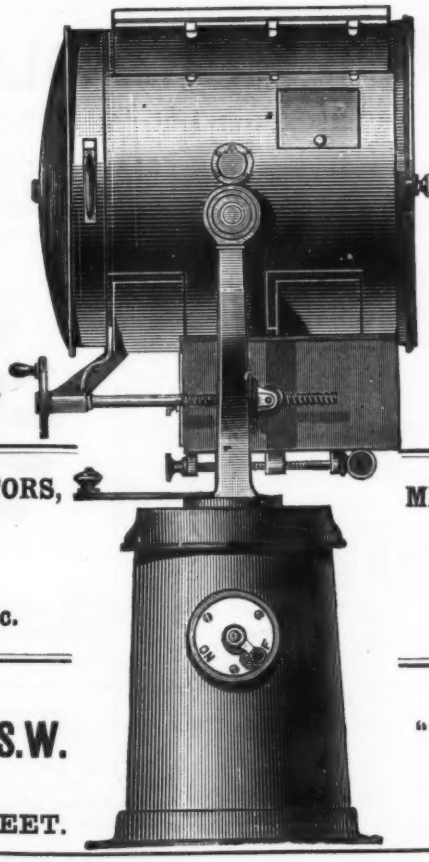

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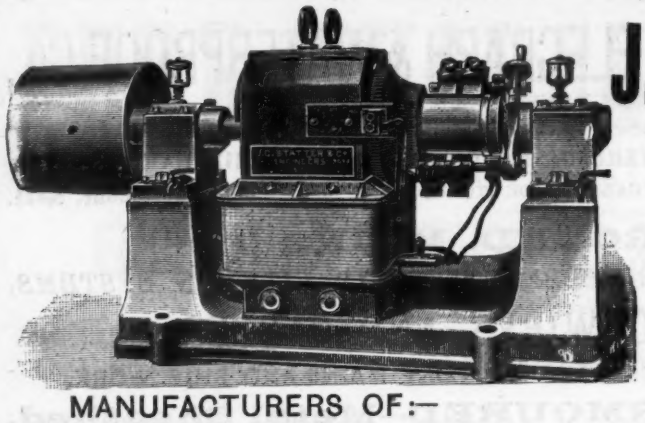

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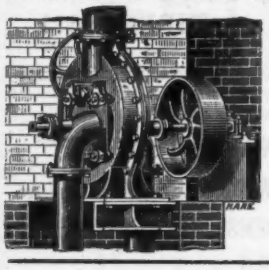

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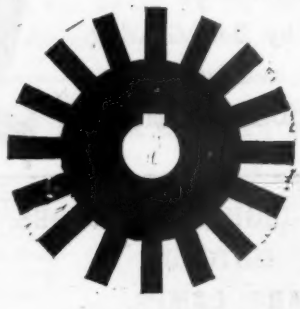

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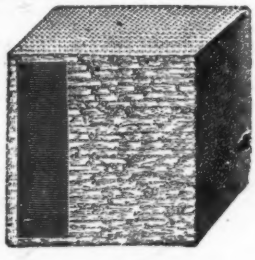

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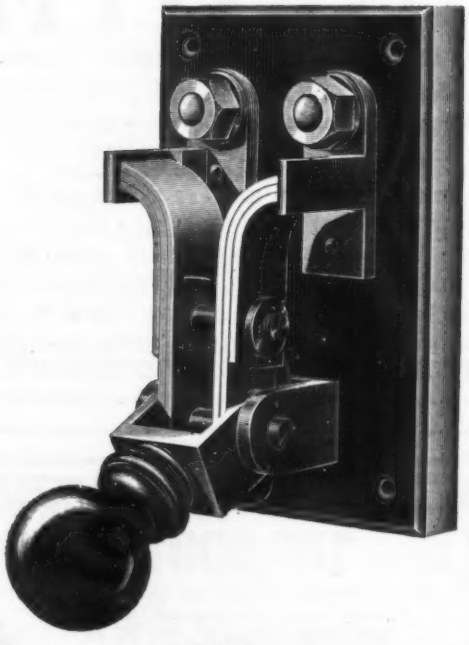

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INDEX TO ADVERTISEMENTS.

The names of Advertisers, whose announcements are ordered for a series, are entered under any one Heading in this Index free of charge, but if repeated under other headings, 6d. per week is charged for each additional entry.

Accumulators. PAGE
Crompton-Howell Elec. S. Co. ...
Drake & Gorham ... ...
Electrical Power Storage Co. ... 14
Epstein Accumulator Co. ... 23
J. Stiff & Sons (Boxes only) Sup. 13
Woodhouse & Rawson United ... 13

Arc Lamps.
Johnson & Phillips 1
The Electrical Company Sup. 2
Woodhouse & Rawson United ... 13

Asbestos.
United Asbestos Co. ... ...

Auctioneers and Valuers (Mechanical).
Wheatley Kirk, Price & Goulty Sup. 9

Batteries.
R. Aylmer (Leclanché) ... Sup. 15
Grant & Crowley 8
India-Rubber Co.... 24
Johnson & Phillips 1
Sharp & Kent (Weymersch) ... 6
Telegraph Mfg. Co. ... Sup. 1
Woodhouse & Rawson United ... 13

Battery Jars.—J. Bourne & Son ... 19
J. Stiff & Sons ... ... Sup. 13

Bells.
General Elec. Co., Ld. ... Sup. 8
Sheppard, Allarton & Madeley ...
Woodhouse & Rawson United ... 13

Belting.—Webb & Son ... Sup. 10

Books.
Berly's Universal Elec. Directory 16
Spon & Co. ... ... Sup. 7
Whittaker & Co. ... Sup. 7

Cabinet Work.—W. M. Foxcroft ... 3

Carbons.
Carboid Oil-less Bearing Co. ...
H. & F. Chamberlain 6
Genl. Elec. Co., Ld. (G. Binswanger) Sup. 8
Johnson & Phillips 1
The Electrical Company Sup. 2
Woodhouse & Rawson United ... 13

Castings.—J. & J. Hughes ... Sup. 3
Phosphor Bronze Co. 10

Chemicals.
G. Boor & Co. 15

Dynamos.
Austin & Myers ... ... Sup. 6
Gülcher Electric Light & P. Co. 19
J. H. Holmes & Co. ... Sup. 9
Johnson & Phillips 1
Laurence, Scott & Co. ... ...
Newton Elec. Engineering Works
C. A. Parsons & Co. 7
Rosling & Matthews 19
Ernest Scott & Mountain ... 16
J. G. Statter & Co. 8
The Electrical Company Sup. 2
Woodhouse & Rawson United ... 13
Wray Elec. Engineering Co. ... 3

Ebonite.—Harburg I. R. Comb Co. Sup. 9
D. Moseley & Sons ... ...

Electrical Engineers and Contractors.
J. D. F. Andrews & Co. ... Sup. 13
Appleton, Burbey & Williamson Sup. 5
British Electric Light Co. Sup. 3
Brush Electrical Engineering Co. 12
Callender's Bitumen Tel. &c. Co. 7
Charlesworth, Hall & Co. ...
Crompton & Co. ... ... Sup. 16
Drake & Gorham ... .
Electric Construction Corp. ... 21
Elliott Bros. ... ... Sup. 16
W. T. Goolden & Co. ... Sup. 11
India-Rubber & Telegraph Works Co. 24
Johnson & Phillips 1
Laing, Wharton & Down ...
Laurence, Scott & Co. ... ...
Moon & Wall 6

Electrical Engineers, &c.—*Cont.* PAGE
C. A. Parsons & Co. 7
Paterson & Cooper 23
Rashleigh Phipps & Co. Sup. 9
Reid Bros. 10
Russell & Co. 12
Ernest Scott & Mountain ... 16
Siemens Bros. & Co. 18
Swinburne & Co. ... ...
Telegraph Mfg. Co. ... Sup. 1
The Electrical Company Sup. 2
Western Electric Company Sup. 16
Woodhouse & Rawson United ... 13

Electric Light Fittings.
Appleton, Burbey & Williamson Sp. 5
Benham & Froud... ... Sup. 6
Dorman & Smith 11
Electrical Accessories Co. ... 9
Faraday & Son 12
Genl. Elec. Co., Ld. (G. Binswanger) Sup. 8
A. P. Lundberg ... ...
Strode & Co. ... ...
The Paiste Switch 10
The Electrical Company Sup. 2
Townshend & Co.... ... ...
B. Verity & Sons ... ... Sup. 1
Walsall Electrical Co. 20
Woodhouse & Rawson United ... 13

Engines for Electric Light.
G. E. Belliss & Co. 15
Browett, Lindley & Co. ... Sup. 3
Davey, Paxman & Co. 12
Greenwood & Batley 4
Griffin Gas Engine 15
Marshall, Sons & Co. 19
Priestman's Oil Engine ... ...
Ransomes, Sims & Jefferies ...
Stockport Gas Engine ... ...
Tangyes' Gas Engine 2
Willans & Robinson 15

Fibre.—David Moseley & Sons ...

Fire Insurance.
Phœnix Office ... ...

Forgings.
Harold & Jenkins 8

Fuel Economiser.
E. Green & Son 17

Fuses.
Carboid Oil-less Bearing Co. ...

Glass.—Genl. Elec. Co. (G. Binswanger) Sup. 8
Woodhouse & Rawson United ... 13

Incandescence Lamps.
Edison & Swan United E. L. Co. ...
Woodhouse & Rawson United ... 13

India-Rubber.
India-Rubber, G. P. & Tel. Wks. Co. 24
D. Moseley & Sons ... ...

Institution.
Military & Engineering College Sup. 10

Insulators, &c.—Bourne & Son ... 19
Price, Sons & Co.... 15
Stiff & Sons ... ... Sup. 13
Telegraph Mfg. Co. ... Sup. 1
Woodhouse & Rawson United ... 13

Iron and Steel.—John Lysaght, Ltd. 6
Turner Bros. 6

Ladders.—J. H. Heathman & Co. ... 8

Lubricants.
G. Skudder & Co. 9
W. H. Willcox & Co. 3

Magnet Steel.—G. P. Wall Sup. 3

Manufacturing Electricians.
Dorman & Smith 11
Elliott Bros. ... ... Sup. 16
Hartmann & Braun ... ...
King, Mendham & Co. ... Sup. 10
Laurence, Scott & Co. ... ...
Nalder Bros. ... ...
Pilsen Electric Co. ... ...

Manufacturing Electricians—*Cont.* PAGE
Poole & White ... ... Sup. 12
Richard Frères ... ... Sup. 13
Strode & Co. ... ...
Telegraph Mfg. Co. ... Sup. 1
The Electrical Company Sup. 2
Walsall Electrical Company ... 20
James White 5
Woodhouse & Rawson United ... 13

Mica.—F. Wiggins & Sons 3

Motors.
Cuttriss, Wallis & Co. ... Sup. 9
Gülcher Electric Light & P. Co. 19
The Electrical Company Sup. 2

Patent Agents.—H. Gardner ... 3
J. G. Lorrain ... ... Sup. 9

Poles.—Joseph Aird (Wrought Iron & Steel) 2
Johnson & Phillips (Wood and Iron) 1

Porcelain Appliances.
John Dimmock & Co. ... Sup. 3
Dorman & Smith 11
Genl. Elec. Co., Ld. (G. Binswanger) Sup. 8
Woodhouse & Rawson United ... 13

Porous Cells.—J. Stiff & Sons Sup. 13

Pulleys, Shafting, &c.
J. Bagshaw & Sons 8

Railway Signals.—Saxby & Farmer 12

Screws.—Davis & Timmins ... 22

Stampings.—Harold & Jenkins ... 8

Telegraph Engineers.
Johnson & Phillips 1
Siemens Bros. & Co. 18
Telegraph Mfg. Co. ... Sup. 1

Telephones.
O. Berend & Co. ... ...
Collier-Marr Telephone, &c., Co.
Consol. Telephone C. & M. Co. ... 7
Gent & Co. 4
International Electric Co. ...

Tenders.

Tools, &c.
Alfred Herbert ... ...
C. Churchill & Co. ... Sup. 6
H. Milnes 6

Tubes.—Joseph Aird ... ...

Turbines.—Gilbert Gilkes & Co. ... 8

Typewriter.
Caligraph ... ...

Underground Conduits.
Internl. Electric Subway Co. Sup. 6

Vulcanite.
Harburg I. R. Comb Co. ... Sup. 9

Wire (Covered).
British Insulated Wire Co. Sup. 13
Fowler-Waring Cables Co. ...
W. T. Glover & Co. 2
W. T. Henley's Telg. Works Co. 4
London Electric Wire Co. ... 5
Phillips Bros. 23
W. Rickard ... ...
Telegraph Mfg. Co. ... Sup. 1
United Electric Wire Co. ... 6
Woodhouse & Rawson United ... 13

Wire (Uncovered).—Davis & Timmins 22
Phosphor Bronze Co 10
Ramsden, Camm & Co. ... Sup. 13
F. Smith & Co. 3

Wire Covering Machinery.
Johnson & Phillips ... Sup. 13

Wood Casings.
Genl. Elec. Co., Ld. (G. Binswanger) Sup. 8
J. F. & G. Harris 6
Vigers Bros. ... ... Sup. 10
Woodhouse & Rawson United ... 13

Wood Turnery.
Irvin & Sellers ... ... Sup. 13

MISCELLANEOUS ADVERTISEMENTS *relating to Situations, Articles for Sale and Wanted, &c., &c., appear on Sup. 9 (middle of paper).*

CROMPTON & CO., LIMITED, SEE SUP. 16.

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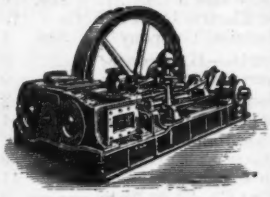

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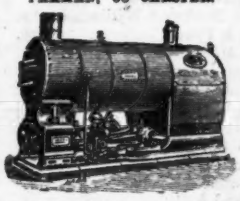

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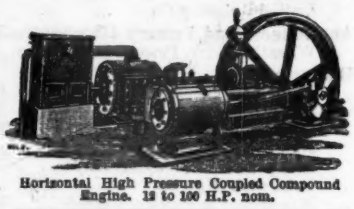

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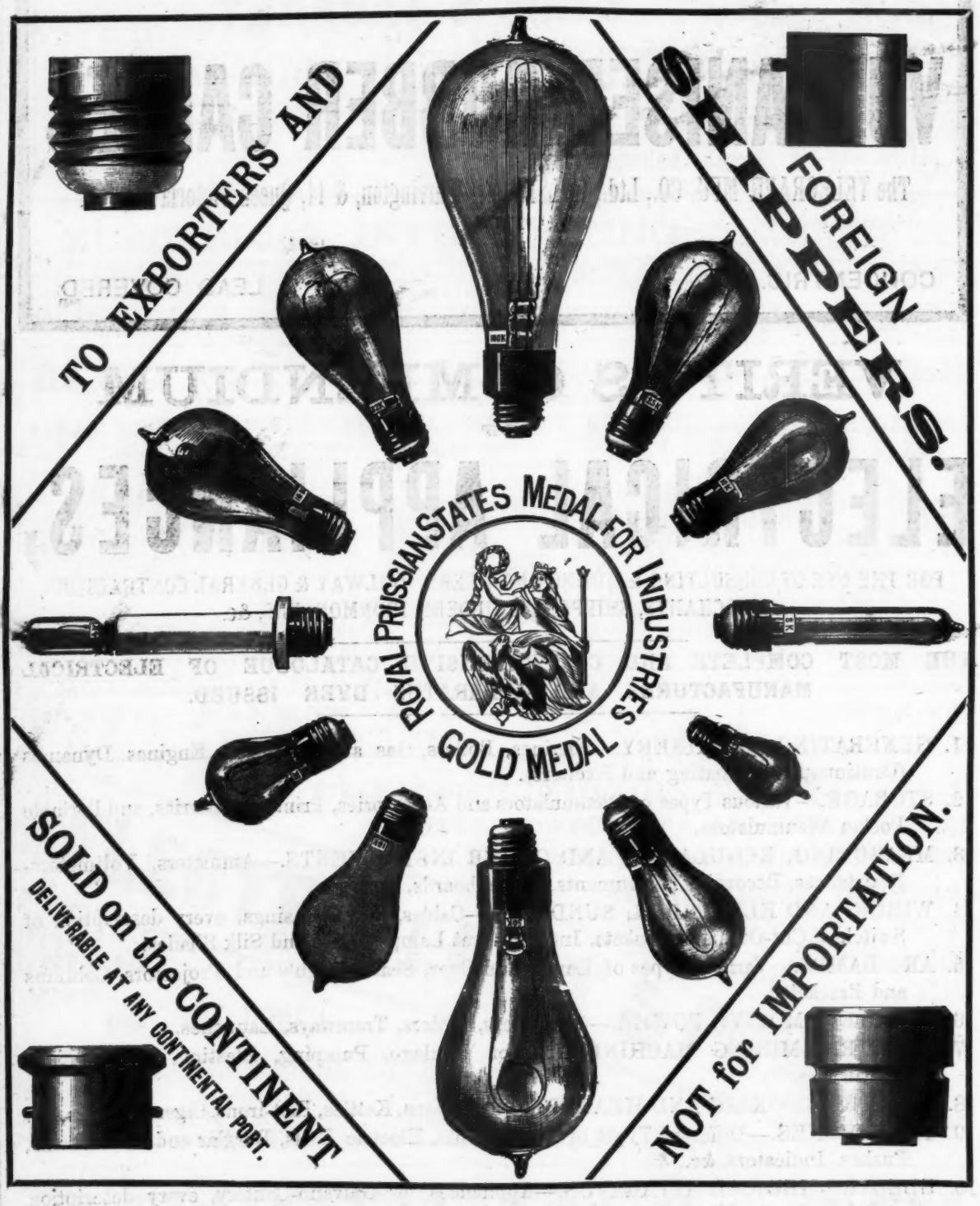

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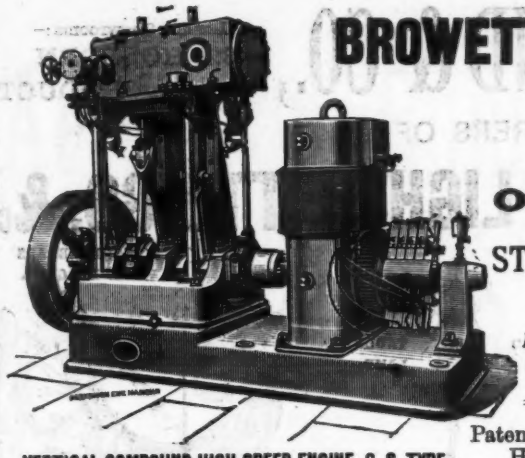

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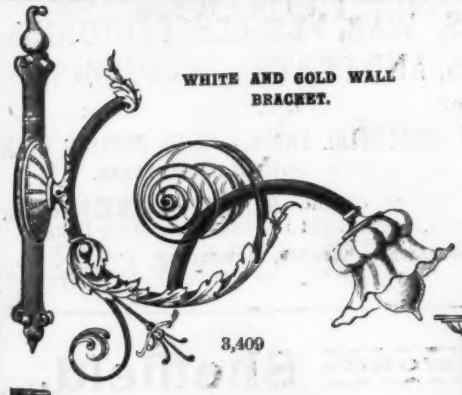

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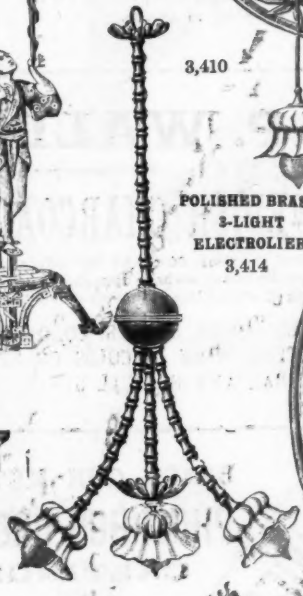

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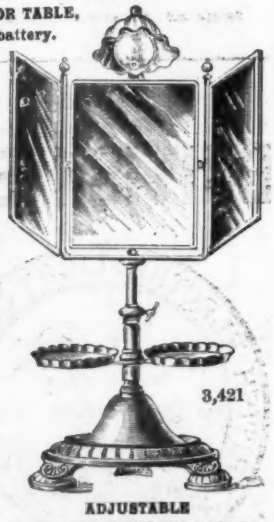

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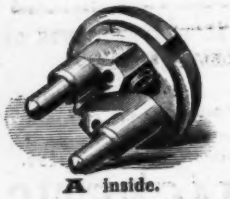

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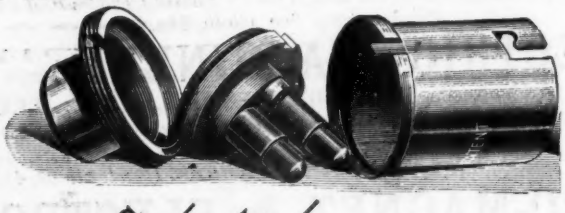

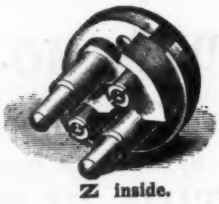

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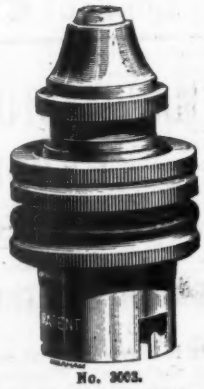

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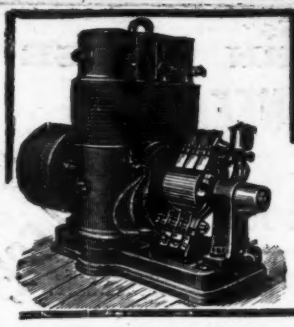

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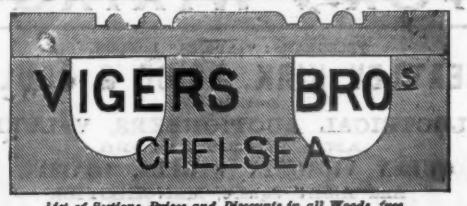

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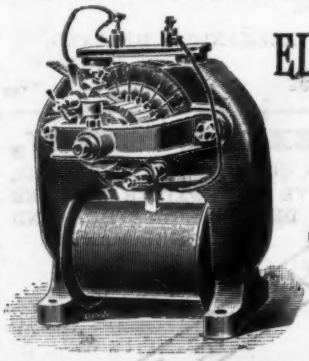

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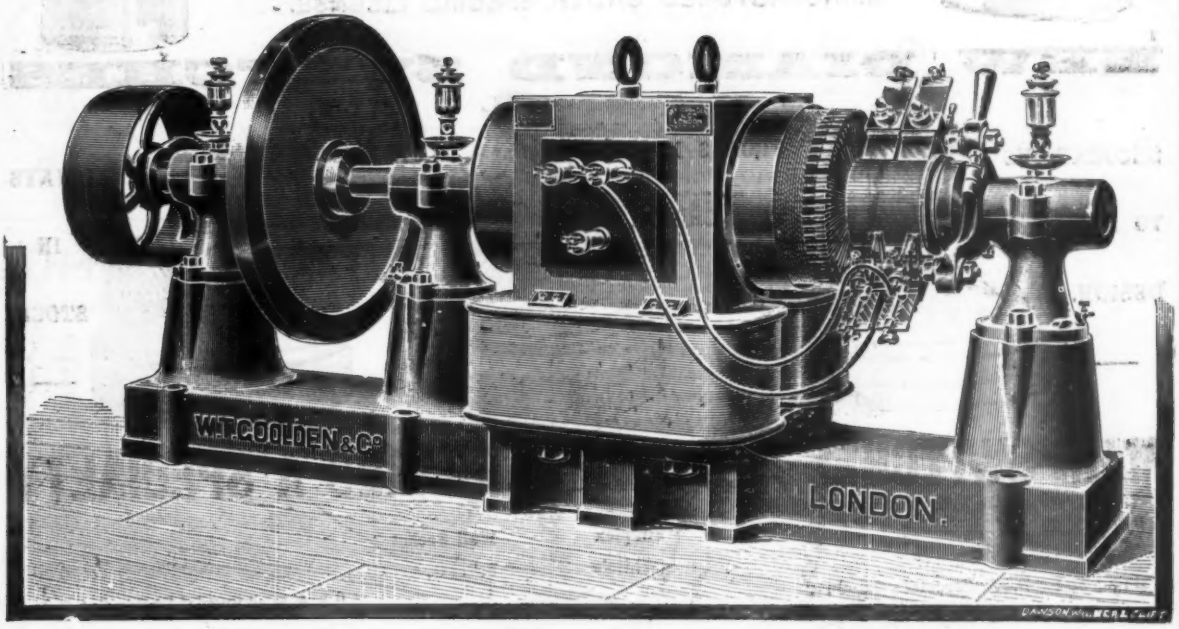

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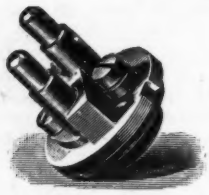

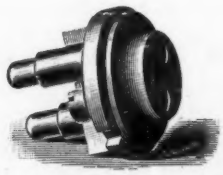

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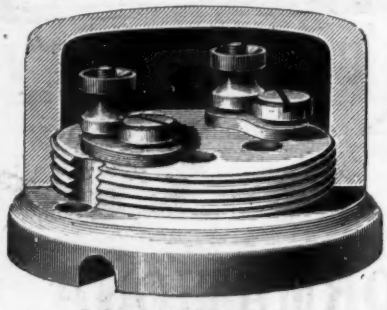

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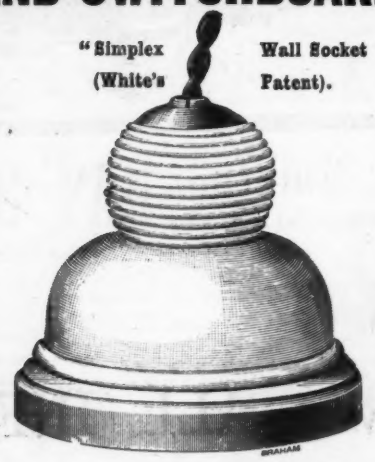

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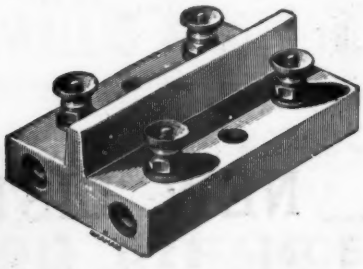

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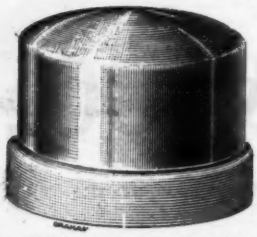

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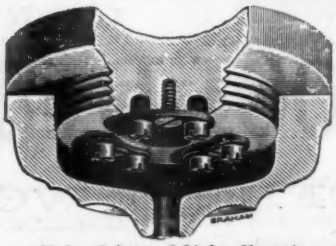

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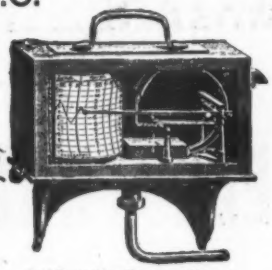

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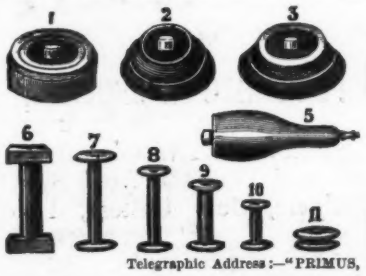

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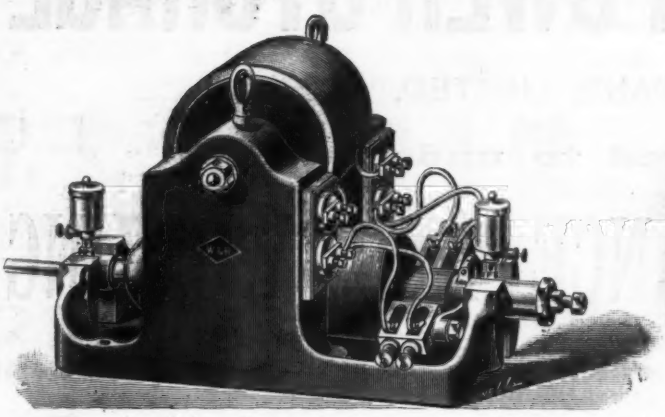

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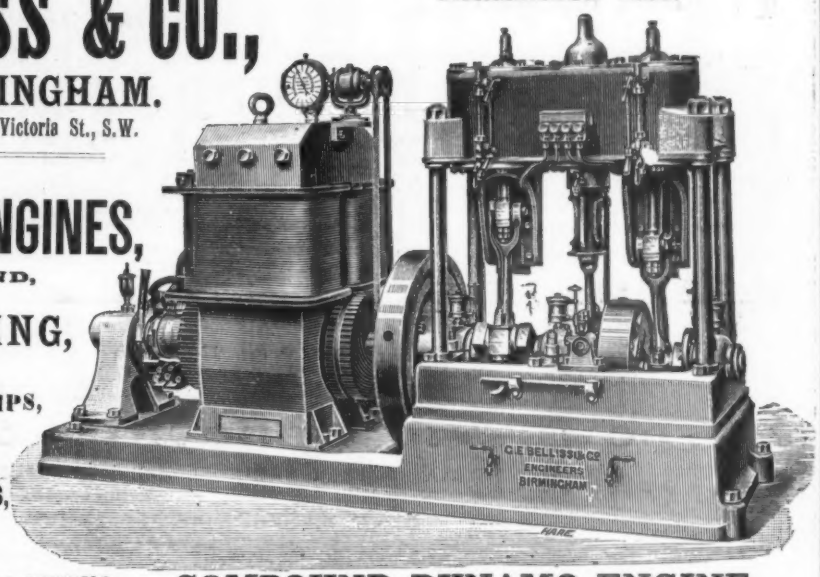

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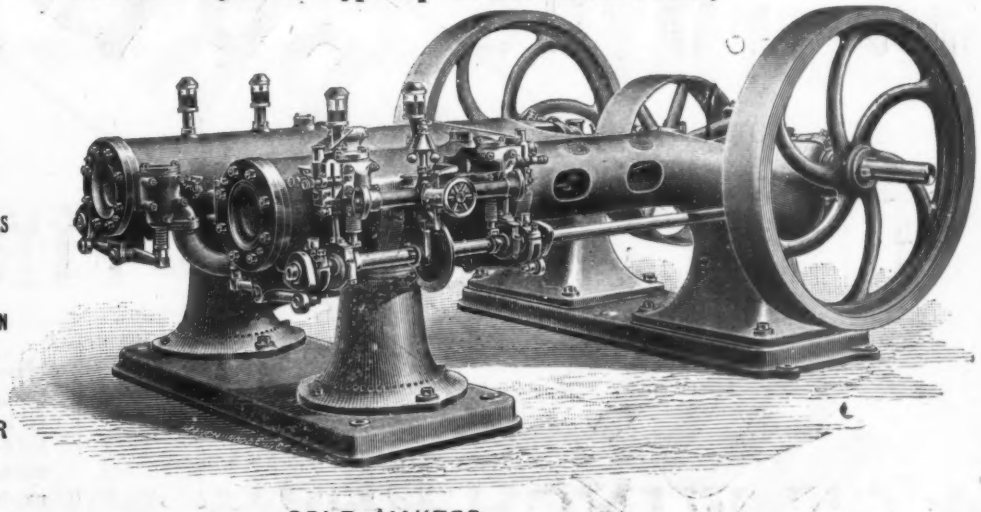

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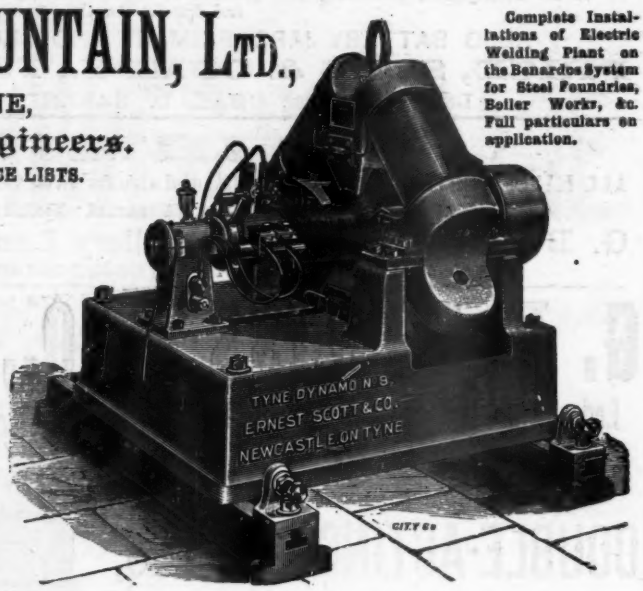

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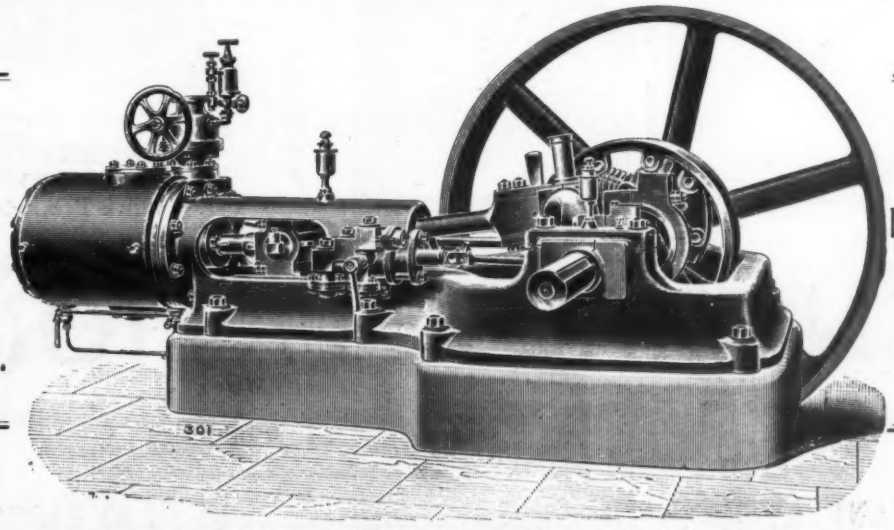

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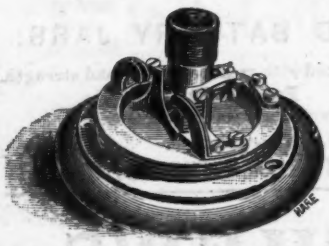

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Press Once to Light the Lamp, which is Extinguished by a Second Push.

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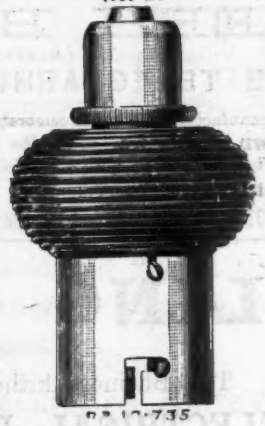

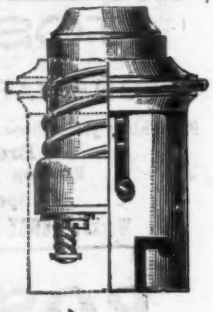

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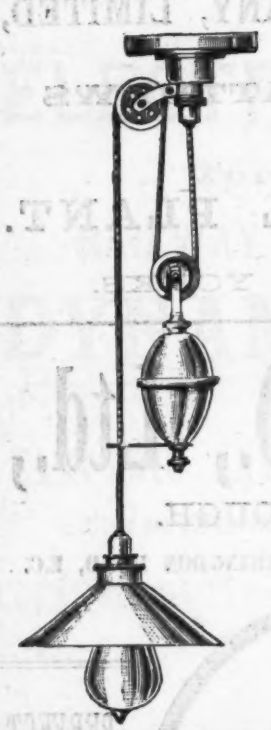
HAS SLATE BASE,

WHICH MAY BE REMOVED FOR WIRING,

BUFFERS AND DISCS BEING SAFELY RECESSED.



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Pressing the Button alternately Lights and Extinguishes a Lamp, or group.

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Specially suited for Testing the Conditions of Accumulators.

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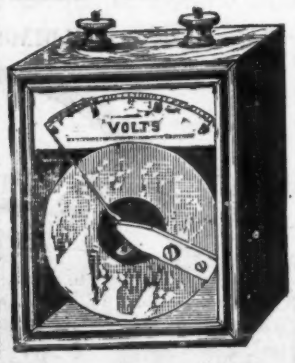

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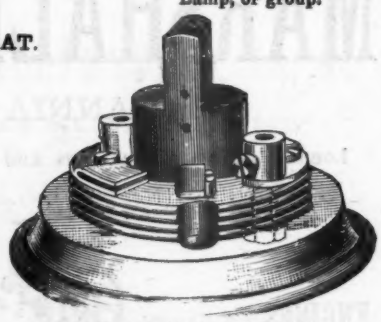

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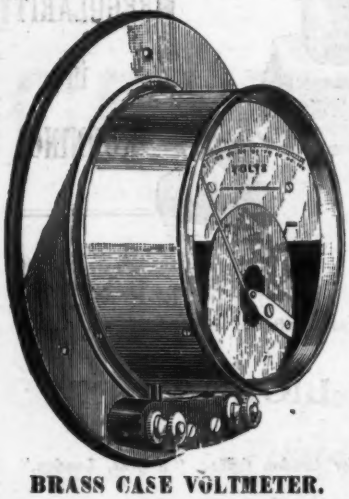

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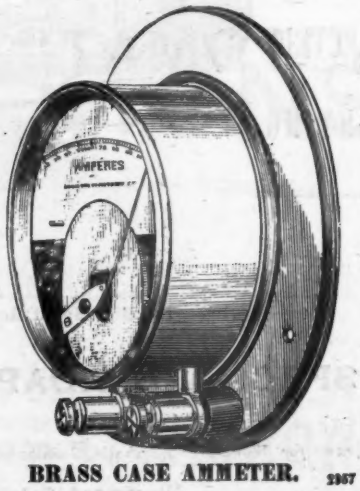

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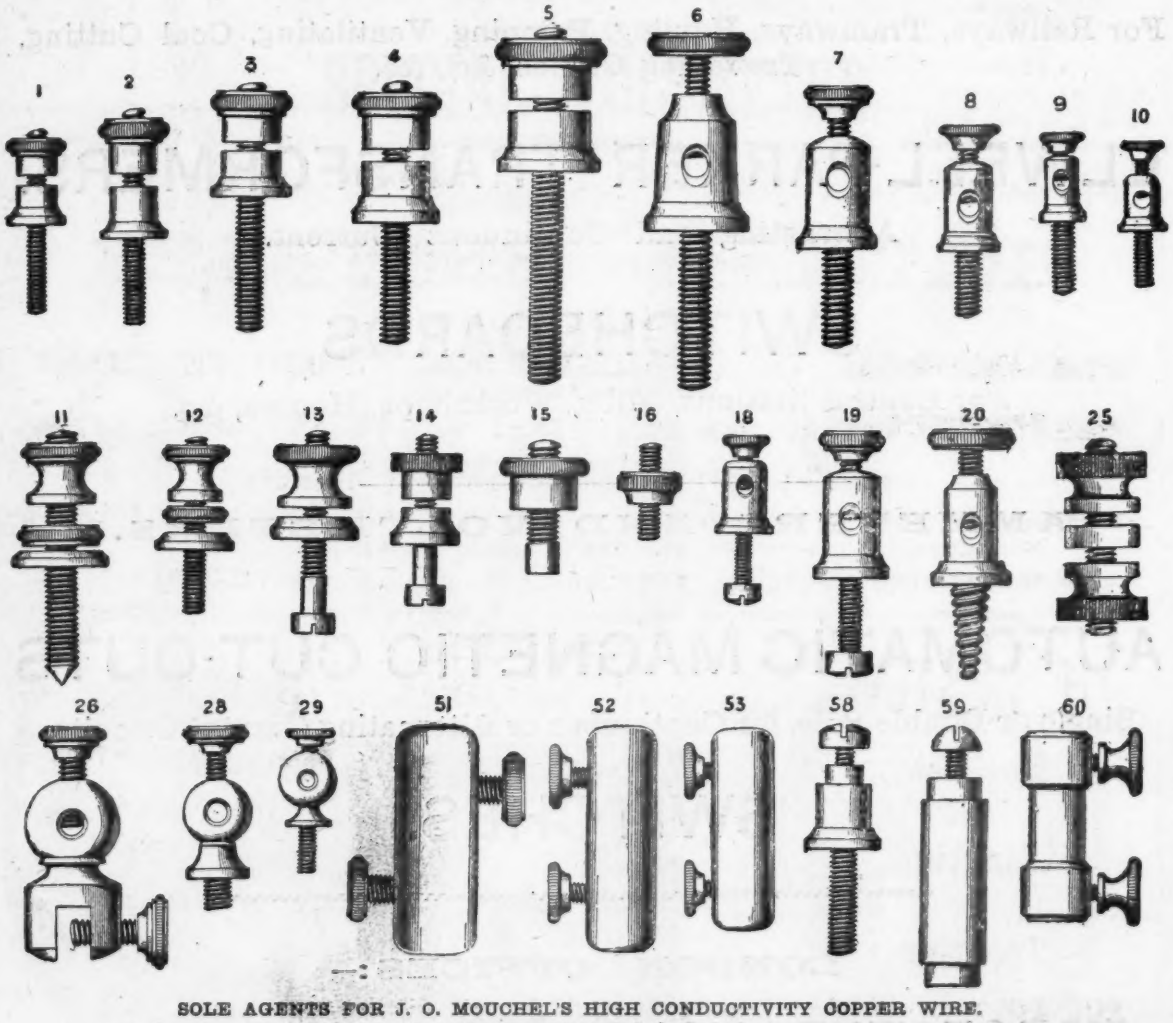

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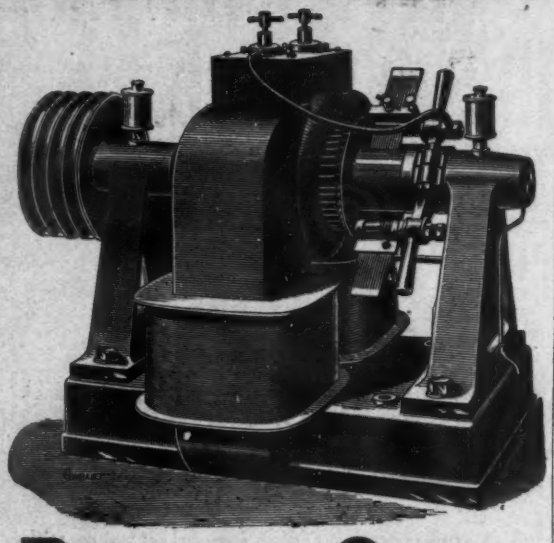

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ELECTRIC LIGHT & TELEPHONE APPARATUS
OF EVERY DESCRIPTION.

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Size.	OUTPUT IN WATTS.	Difference of Potentials in Volts.	No. of 60 Watt Lamps.	Approx. Speed.	Approx. Horse Power.	PRICE.	Extra for Bedding Rails and Tightening Screws.	Extra for Fly Wheel for Gas Engine.
						£	£ s.	£ s.
1 S	600	30 to 60	10	1,800	1	20	1 10	2 0
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3 S	1,200	50 to 80	20	1,700	2	28	2 10	3 0
4 S	2,100	50 to 110	35	1,600	3½	38	3 0	3 10
5 S	3,000	60 to 110	50	1,520	5	44	3 5	4 0
6 S	4,500	60 to 110	75	1,480	7½	55	3 15	4 10
7 S	6,000	60 to 120	100	1,360	10	65	4 5	5 0
8 S	9,000	60 to 120	150	1,280	15	85	5 0	5 10
9 S	12,000	60 to 120	200	1,180	20	105	6 0	6 0
9½S	15,000	80 to 150	250	1,100	25	120	7 0	—
10 S	18,000	80 to 150	300	1,020	30	135	8 0	—
10½S	21,000	80 to 180	350	1,000	35	155	9 0	—
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For the same output, price 15 per cent. over above prices.

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6D	9,000	65 to 110	150	750	15	110	6 0
7D	12,000	65 to 110	200	700	20	130	7 0
8D	18,000	65 to 110	300	650	30	170	8 0
9D	24,000	65 to 110	400	600	40	220	10 0
10D	36,000	110 to 125	600	500	60	290	12 0
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12D	60,000	110 to 125	1,000	400	100	450	16 0

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STRONG
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FEW PLATES
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LARGE CAPACITY
HIGH DISCHARGES

Working Rate for Type R3

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Charge. Amp.		Discharge. Amp.	Capacity. Amp.-hours.
Up to 26	at	13	130
	,,	20	120
	,,	26	105
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Made to a Capacity up to 10,000 Amp. Hours. 5030

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